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A new species of Andean lizard *Proctoporus* (Squamata: Gymnophthalmidae) from montane forest of the Historic Sanctuary of Machu Picchu, Peru

¹Luis Mamani, ²Noemí Goicoechea, and ³Juan C. Chaparro

^{1,3}Museo de Historia Natural, Universidad Nacional de San Antonio Abad del Cusco, Plaza de Armas s/n (Paraninfo Universitario), Cusco, PERU

²Department of Biodiversity and Evolutionary Biology, Museo Nacional de Ciencias Naturales-CSIC, C/ José Gutiérrez Abascal 2, 28006 Madrid, SPAIN

Abstract.—We describe a new species of lizard assigned to the genus *Proctoporus* from the Historic Sanctuary of Machu Picchu in the Department of Cusco (southeastern Peru) where it inhabits a montane forest region at an elevation between 2,760–2,800 m. The new species is distinguishable from all other species of *Proctoporus* by a unique combination of morphometric, scalation, and color pattern characteristics.

Resumen.—Describimos una nueva especie de lagartija asignada al género *Proctoporus*, proveniente del Santuario Histórico de Machu Picchu en el Departamento del Cusco (Sureste de Perú), habita la región de bosques montanos entre los 2,760–2,800 m de altitud. La nueva especie se distingue de todas las demás especies de *Proctoporus* por la combinación única de caracteres morfométricos, escamación y características en los patrones de coloración.

Key words. Oriental Cordillera, Cusco, Peru, South America, Andean lizard, *Proctoporus*, Natural Protected Area, Cercosaurinae

Palabras clave. Cordillera Oriental, Cusco, Perú, América del Sur, Lagartija andina, *Proctoporus*, Área Natural Protegida, Cercosaurinae

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Introduction

Gymnophthalmid lizards of the genus *Proctoporus* includes eleven species that occur in central and southern Peru, Bolivia, and northern Argentina, and an additional two unnamed species known from Peru (Doan et al. 2005; Goicoechea et al. 2012). These small, semi-fossorial lizards occur in habitats characterized by cloud forest, steppes, cacti, shrubs, and wet puna habitats along the eastern slopes of the central Andes (Doan and Castoe 2003; Doan et al. 2005). The highest diversity of the genus *Proctoporus* occurs in Peru, which includes ten species: *P. bolivianus* Werner 1910; *P. carabaya*; *P. iridescens*; *P. kiziriani* Goicoechea, Padial, Chaparro, Cas-

troviejo-Fisher, and De la Riva 2013; *P. chasqui* (Chávez et al. 2011); *P. guentheri* (Boettger 1891); *P. lacertus* (Stejneger 1913); *P. pachyurus* Tschudi 1845; *P. succulucu* Doan and Castoe 2003; and *P. unsaaciae* Doan and Castoe 2003. Three species, *P. guentheri*, *P. bolivianus*, and *P. xestus* (Uzzell 1969), occur in Bolivia and one, *P. xestus*, reaches northern Argentina and probably Peru (Goicoechea et al. 2013). Taxonomic works published in this century include revisions (e.g., Doan and Castoe 2003; Doan et al. 2005; Goicoechea et al. 2012; Goicoechea et al. 2013) and the description of several new species (Doan et al. 2005; Chávez et al. 2011; Goicoechea et al. 2013). However, the actual diversity of this genus is far from known well, and new species continue to be

Correspondence. Email: ¹luismamanic@gmail.com (Corresponding author); ²n.goicoechea@gmail.com; ³jchaparroauza@yahoo.com

found as herpetological surveys are carried out in previously unexplored or poorly known areas.

Recent biological exploration in the southern Peruvian Cordillera Oriental of the Andes has revealed the existence of a new species of gymnophthalmid lizard in the montane forest region within the national protected area of the Historic Sanctuary of Machu Picchu. The species is described herein and assigned to the genus *Proctoporus*.

Materials and Methods

Specimens were collected by hand, euthanized with Halatal, fixed in 10% formalin, and later transferred to 70% ethanol for long-term museum storage. The specimens were deposited at the Museo de Historia Natural de la Universidad Nacional de San Antonio Abad de Cusco (MHNC) in Peru. Morphological data were obtained from preserved specimens of all known species of *Proctoporus*. Because only two specimens (one adult male and one juvenile) of *Proctoporus chasqui*, were examined, we used data from Chávez et al. (2011). Twenty-three qualitative and meristic morphological characters

(Table 1) used in previous studies on gymnophthalmid systematics were examined for 120 specimens (Appendix I). Character definition and usage follow Uzzell (1970) and Doan and Castoe (2003). Drawings were elaborate using a stereo microscope with camera lucida.. Coloration in life is based on the field notes and photography by LM. Geographic coordinates were taken using a global positioning system (GPS) device and geodetic datum WGS 84.

Results

Proctoporus machupicchu sp. nov.

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Figures 1–3.

Proposed standard English name:
Machu Picchu Andean Lizard

Proposed standard Spanish name:
Lagartija Andina de Machu Picchu

Table 1. Measurements (mm) of three specimens of *Proctoporus machupicchu* sp. nov. and the addition of Fig. 3 G, specimen of subadult male not collected.

Characters (measurements mm)	MHNC13373	MHNC13362	MHNC11815	Not collected (Fig. 3 G)
	Subadult male	Adult female	Adult female	Subadult male
Snout-vent length	20.80	41.20	46.70	< 28,80
Tail length	32.30	60.82	61.40	—
Head length	8.50	10.70	11.00	—
Head width	4.80	5.80	5.70	—
Femoral pores	0	0	0	6
Supralabials	6–7 (left-right)	6	6	6
Loreal scale	PRESENT	PRESENT	PRESENT	PRESENT
Supraoculars	3	3	3	3
Genials	6	6	6	5
Postparietals (Occipitals)	3	3	3	3
Temporals	12	9	10	10
Scales around midbody	39	38	39	—
Transversal dorsal scale rows	23	22	24	—
Transversal ventral scale rows	10	10	10	10
Longitudinal dorsal scale rows	38	39	39	38
Longitudinal ventral scale rows	21	21	21	21
Lamellae under 4th finger	10	11	10	—
Lamellae under 4th toe	16	16	17	—
Postoculars	2	2	2	2
Superciliaries	4	4	4	4
Frontal	1.50	2.10	2.00	—
Frontonasal	1.50	1.95	2.10	—
Head length/Head width	1.77	1.84	1.93	—
Tail length/SVL	1.12	1.48	1.31	—
Frontal/frontonasal proportion	1.00	1.08	0.95	—

Holotype: (Fig. 1; 2 A–C; 3 A–B), adult female, MHNC 13362 (field number LM 834), Peru, Department of Cusco, Province Urubamba, District Machu Picchu, from Aobamba (13° 14' 17" S; 72° 33' 15" W), 2,760 m, collected by Luis Mamani, Frank P. Condori, and Juan C. Chaparro on 16 June 2013.

Paratypes: MHNC 13373, field number LM 845, (Fig. 3 E–F), immature male, same data as holotype; MHNC 13513, adult female (field number LM 637, Fig. 2 D–F; 3 C–D), Peru, Department of Cusco, Province Urubamba, District Machu Picchu, from Wiñaywayna (13° 11' 33.72" S; 72° 32' 18.66" W), 2,800 m, collected by Luis Mamani, Kateryne Pino, Alexander Pari, Andres Garcia, and Gerardo Ceballos on 11 September 2012.

Diagnosis: (1) Frontonasal length equal to the frontal length; (2) nasoloreal suture present in all specimens; (3) Loreal scale present, not in contact with supralabials; (4) supraoculars three; (5) superciliaries four, first not expanded onto the dorsal surface of the head; (6) postoculars two; (7) palpebral disc made up of a single, undivided scale; (8) four supralabials anterior to the posteroventral angle of the subocular; (9) three pairs of genials in medial contact; (10) dorsal body scales quadrangular, keeled; (11) transverse rows of dorsals 38–39; (12) transverse ventral rows 21; (13) a continuous series of small lateral scales separating dorsals from ventrals; (14) posterior cloacal plate made up of six scales in both sexes; (15) anterior preanal plate scales paired; (16) femoral pores present or not in males, when is pres-

ent six per hind limb (Fig. 3 G), absent in females; (17) preanal pores absent; (18) subdigital lamellae on toe IV 16–17; subdigital lamellae on finger V 10–11; (19) limbs overlapping when adpressed against body in adults; (20) limbs pentadactyl, digits clawed; (21) dorsal and lateral surfaces of head dark brown; lip irregularly yellow or orange-cream stripes; ventral surface of head and preular region cream or orange, with or without irregular black blotches; venter black or dark gray with cream or cream-orange spots on the posterior margin of some scales, in male juveniles is orange with black blotches.

All specimens of *Proctoporus machupicchu* have an undivided palpebral eye disc, a putative synapomorphy of the genus *Proctoporus* (Doan and Castoe 2005; Uzzell 1970). *Proctoporus machupicchu* can be distinguished from all other species of the genus, except for *P. iridescens*, by the presence of three pairs of genials in medial contact (two in all other species of *Proctoporus*). It can be distinguished from *P. iridescens* by having four supralabials anterior to the posteroventral angle of the subocular, by the presence of a loreal scale and a nasoloreal suture (three supralabials, loreal scale, and nasoloreal suture absent in *P. iridescens*). It can further be differentiated from *P. pachyurus* by having three supraoculars not fused with superciliaries (four supraoculars in *P. pachyurus*, first fused with first superciliary), and 38–39 transverse dorsal scale rows (47–60 in *P. pachyurus*); from *P. sucullucu* by having a frontonasal scale equal in length to the frontal scale (frontonasal scale longer than the frontal scale in *P. sucullucu*), and loreal scale not in contact with the supralabials (in contact in *P. sucullucu*); from

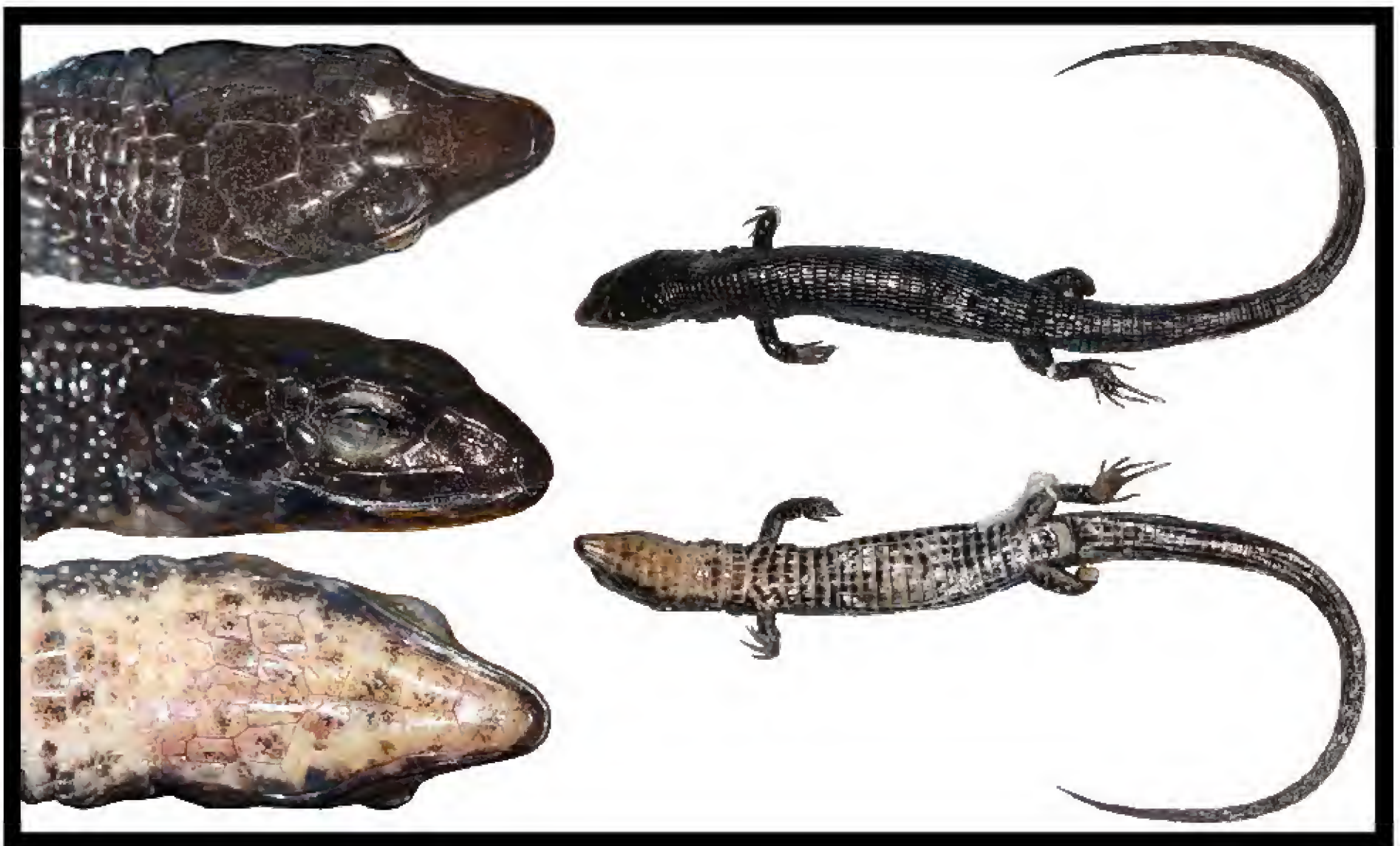


Fig. 1. Holotype of *Proctoporus machupicchu* (MHNC 13362; SVL 41.2 mm).

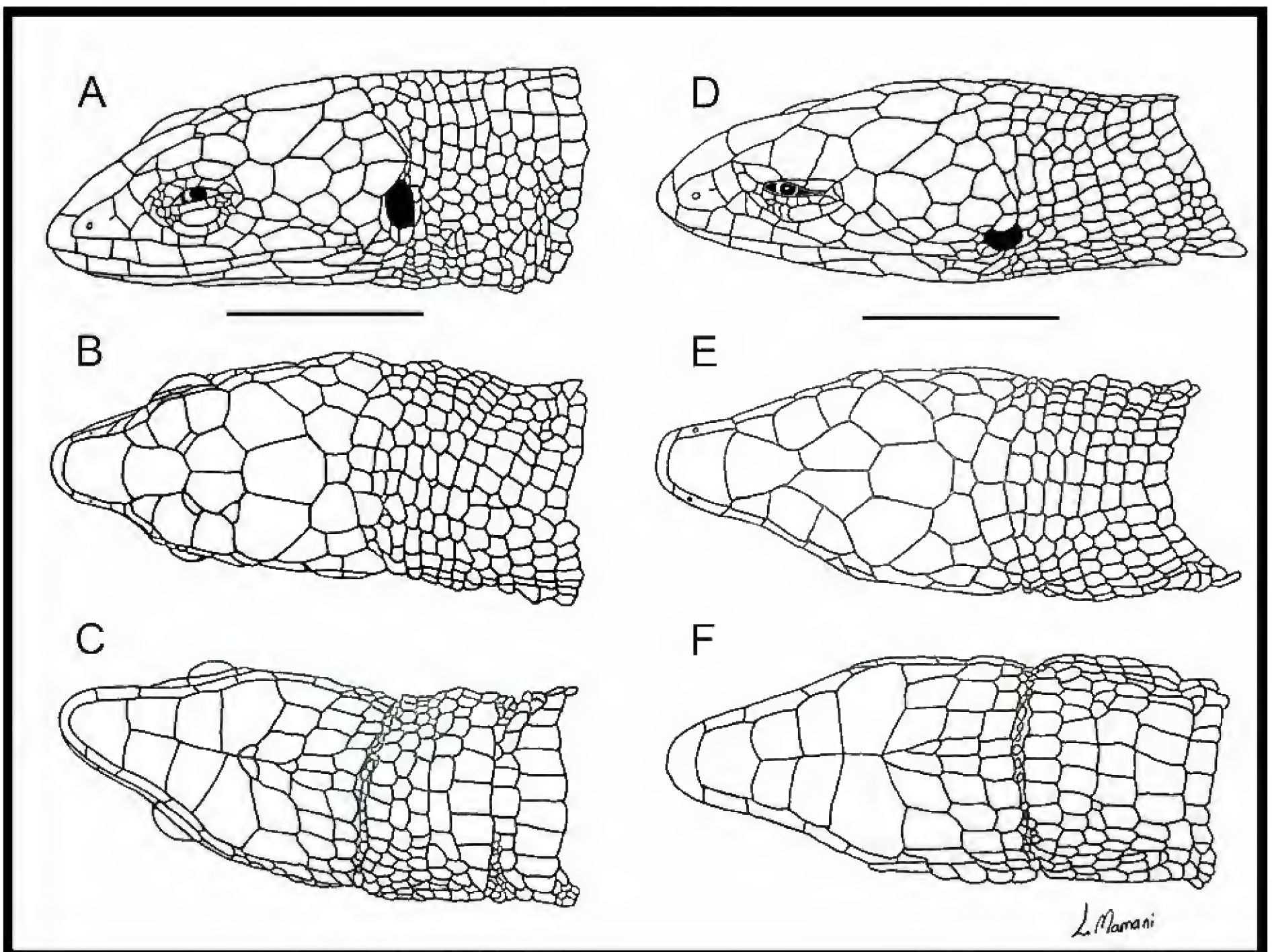


Fig. 2. (A, B, C) Head of the holotype of *Proctoporus machupicchu* (MHNC 13362), lateral, dorsal, and ventral view; and (D, E, F) Paratype (MHNC 13373) lateral, dorsal, and ventral view of the head. Scale bar 5 mm.

P. bolivianus by having frontonasal length equal to the frontal length (frontonasal longer than frontal scale in *P. bolivianus*); first superciliary not fused with first supraocular (fused in *P. bolivianus*); from *P. unsaacae* and *P. guentheri* by the absence of a series of continuous lateral ocelli, loreal scale not in contact with supralabials, and the absence of a pair of enlarged preangular scales in contact (present in *P. unsaacae* and *P. guentheri*, loreal scale in contact with supralabials in *P. unsaacae* and a pair of enlarged preangular scales in medial contact in *P. sucullucu*); from *P. carabaya* and *P. kiziriani* by having a first supraocular not fused with the first superciliary, (fused in *P. carabaya* and *P. kiziriani*) and limbs overlapping when adpressed against body (not overlapping in *P. carabaya* and *P. kiziriani*); from *P. lacertus* by having first supraocular not fused with the first superciliary (fused in *P. lacertus*), and the presence of a loreal scale (absent in *P. lacertus*); from *P. xestus* by the lack of prefrontal scales (present in *P. xestus*) and the existence of keeled dorsal scales (smooth in *P. xestus*); and from *P. chasqui* by the lack of prefrontal scales (present in *P. chasqui*), supraoculars three (four in *P. chasqui*), and femoral pores absent in females (present in females of *P. chasqui*).

Description of holotype: Adult female, snout-vent length (SVL) 41.2 mm, tail length 60.8 mm; head scales smooth, rounded in dorsal and lateral view, without striations or rugosities; rostral scale wider (1.9 mm) than tall (0.9 mm), meeting the supralabials on either side at the top of the supralabials, becoming higher medially, in contact with frontonasal, nasals, and first supralabials; frontonasal longer than wide, equal in length with frontal, widest posteriorly, in contact with rostral, nasals, anterior most supraocular, and frontal; prefrontals absent; frontal longer than wide, roughly polygonal, not in contact with superciliaries, in contact with frontonasal, first two supraoculars, and frontoparietals; frontoparietals polygonal (right scale divided on the right anterior side), in contact with frontal, second and third supraoculars, parietals, and interparietal; supraoculars three, middle scale divided on the posterior corner (in contact with frontoparietals on both sides), all in contact with superciliaries, third in contact with frontoparietal, parietal, and postocular; interparietal longer than wide, polygonal, in contact with frontoparietals anteriorly, with parietals laterally, and with occipitals (or postparietals) posteriorly; parietals polygonal, lateral suture in contact with temporals and



Figure 3. Dorsal and ventral views of living specimens of *Proctoporus machupicchu*. **A–B** adult female (MHNC 13362); **C–D** adult female (MHNC 13513); and **E–F** immature male (MHNC 13373); and **G** not collected of immature male showing femoral pores.

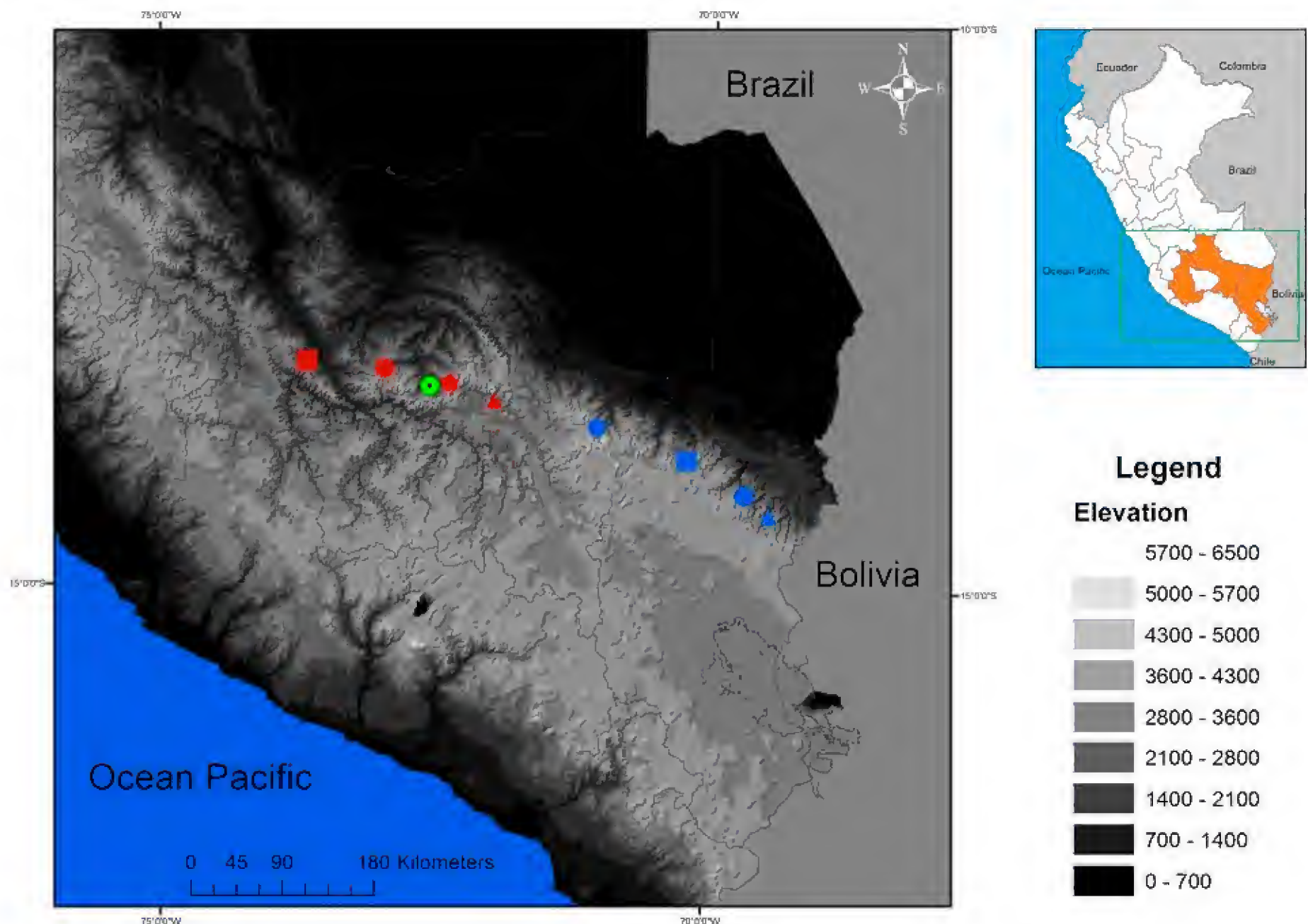


Figure 4. Map showing the distribution of *Proctoporus* species known from southeast of Peru, based on species listed in Appendix I and in Uzzell (1970), Doan and Castoe (2003), Doan et al. (2005), Chavez et al. (2011), and Goicoechea et al. (2013). Green circle, *Proctoporus machupicchu* sp. nov.; blue triangle, *P. bolivianus*; blue square, *P. carabaya*; red square, *P. chasqui*; blue circle, *P. iridescens*; blue pentagon, *P. kiziriani*; red circle, *P. lacertus*; red triangle, *P. unsaaca*; and red pentagon *P. sucullucu*.

postoculars, diagonally with temporals, posteriorly with occipitals, anteriorly with third supraoculars and frontoparietals; three occipitals, smaller than parietals, medial pentagonal, smaller than the laterals. Nasal divided, longer than high, in contact with first and second supralabials; loreal present, not in contact with the supralabials, in contact with nasal, first superciliary, and frenocular; four superciliaries, first not fused with the first supraocular; two preoculars, upper in contact with the first superciliary and loreal scales, lower in contact with frenocular, and first subocular; frenocular roughly pentagonal, in contact with the second and third supralabials, lower preoculars, first subocular, and loreal scales; palpebral disc made up of a single transparent scale; three suboculars; two postoculars; temporals smooth, polygonal; four supralabials anterior to the posteroventral angle of the suboculars. Mental wider (1.9 mm) than long (1.05 mm), in contact with the first infralabial and postmental posteriorly; postmental single, pentagonal, in contact with the first infralabials and the first pair of genials; three pairs of genials in medial contact, anterior pair in contact with the first and second infralabials on the right side and in contact with the second on the left side; second pair of genials in contact with the second and third infralabials; third pair of genials in contact with the third

and fourth infralabials laterally; one pair of chin shields, separated by four smaller median pregenials; eight gular scale rows; small lateral neck scales, round and smooth. Dorsal scales rectangular, longer than wide, juxtaposed, slightly keeled, in thirty-nine transverse rows; twenty-three longitudinal dorsal scale rows at midbody; continuous lateral scale series, smaller than dorsals, and partially hidden in lateral fold; reduced scales at limb insertion regions present; twenty-two transverse ventral scale rows; ten longitudinal ventral scale rows at midbody; anterior preanal plate scales paired; six posterior preanal plate scales, lateralmost scales small; scales on the tail rectangular (fewer square), juxtaposed; dorsal and dorsolateral caudal scales slightly keeled anteriorly, smooth posteriorly; ventrolateral caudal scales smooth; midventral subcaudal scales wider than the adjacent scales, almost square, anteriormost midventral subcaudal scales subimbricate. Limbs pentadactyl; digits clawed; dorsal brachial scales polygonal, subequal in size, subimbricate, smooth; roundish ventral brachial scales, subimbricate, smooth; dorsal antebrachial scales polygonal, subequal in size, smooth; ventral antebrachial scales polygonal, smaller than dorsals; dorsal manus scales polygonal, smooth, subimbricate and arranged in three rows; palmar scales small, rounded, and juxtaposed, domelike; dorsal scales

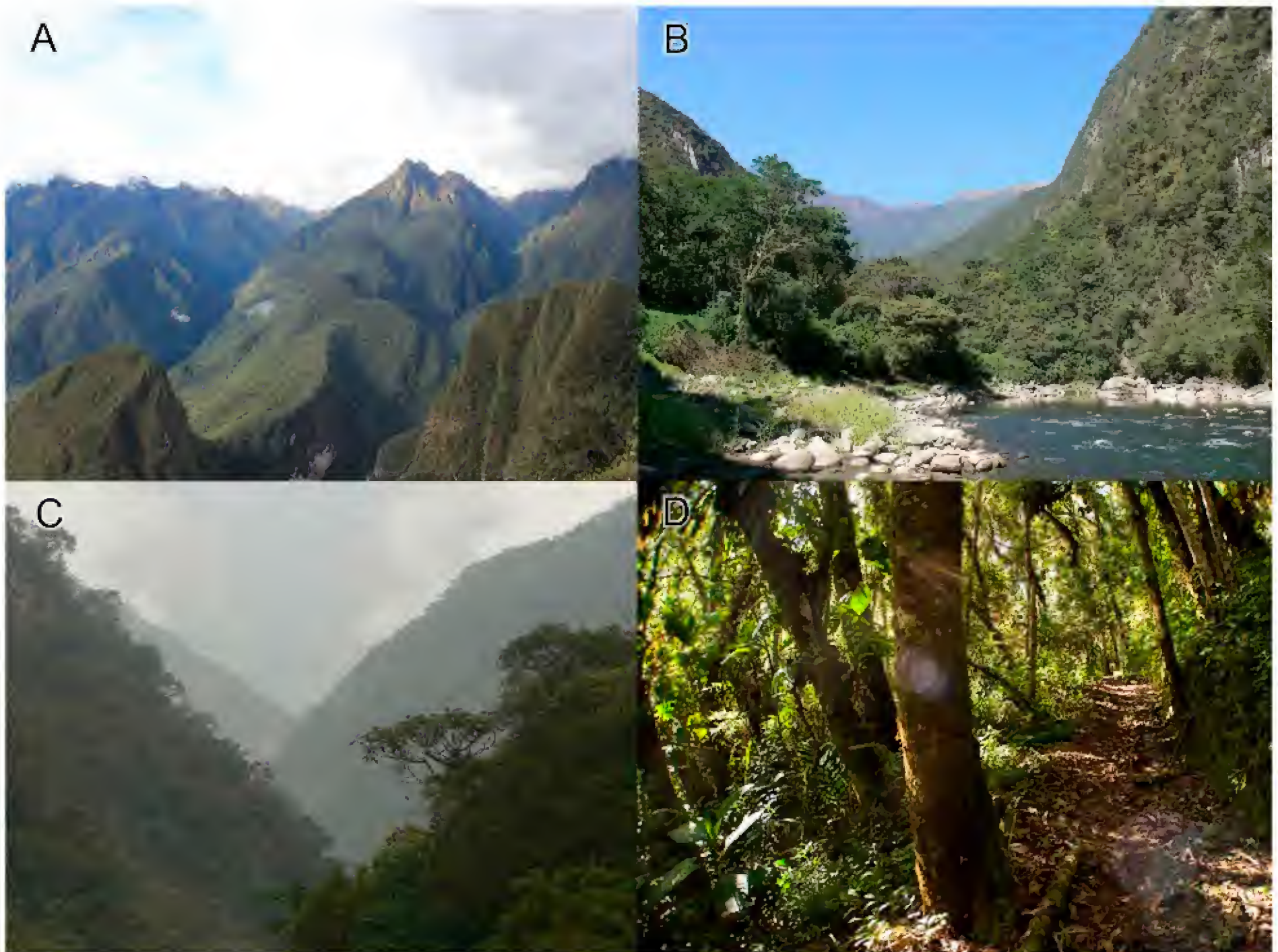


Figure 5. Type locality of *Proctoporus machupicchu*: (A, C) Montane forest, (B) Urubamba River, (D) Habitat of *Proctoporus machupicchu*. Photo: (6 A–C) Luis Mamani; 6 D (Javier Farfan).

on fingers smooth, quadrangular, covering dorsal half of digit, and overhanging subdigital scales, two on finger I, four on II, six on III, six on IV, and four on V; scales on anterodorsal surface of thigh polygonal, smooth, subimbricate; scales on posterior surface of thigh small, rounded, and juxtaposed; scales on ventral surface of thigh small, enlarged, and smooth; femoral pores absent; preanal pores absent; scales on anterior surface of crus polygonal, smooth, juxtaposed, decreasing in size distally; scales on anterodorsal surface of crus rounded, juxtaposed; scales on ventral surface of crus polygonal, enlarged, smooth, flat, and subimbricate; scales on dorsal surface of toes polygonal, smooth; overhanging supradigital lamellae, two on toe I, five on II, nine on III, twelve on IV, seven on V; subdigital lamellae single, four on toe I, eight on II, eleven on III, sixteen on IV, ten on V; limbs overlapping when adpressed against the body.

Coloration in preservative: Dorsal and lateral surfaces of head dark brown; ventral surface of head cream with clusters of light and dark brown, and scales with black spots inside. Gular region similar to the head, the macules in anterior side are light brown and diffuse, on posterior side are thick. Lip irregularly barred with cream

coloring. Dorsal surface of the trunk same color as head. Lateral surface of trunk of the same coloration as dorsum, fading to paler brown near venter. Ventral surface of the trunk black with cream spots at posterior margin of each scale. Color of limbs similar to body. Dorsal tail coloration like that of body; ventral surface of tail dark brown with cream spots.

Coloration in life: The coloration is similar to that in preservative, but with orange spots along the ventral surface of the body.

Variation: Scallation and morphometrics of the paratypes are similar to the holotype (Table 1). The coloration in females is variable, the ventral surface of the head and gular region are orange and pale yellow with brown and black spots. In the sub-adult male the coloration in the ventral surface of the head and gular region is an intense orange and extends posteriorly to the ventral surface of the trunk.

Etymology: The specific epithet is an indeclinable word that refers to the distribution of the new species in the Natural Protected Area of the Historic Sanctuary of Ma-

chu Picchu, in the Cordillera of Vilcanota, one of the most important formations in the Andes of southern Peru.

Distribution: *Proctoporus machupicchu* is known only from Aobamba (type locality), and Wiñaywayna, both inside the Historic Sanctuary of Machu Picchu between 2,760–2,800 m (Fig. 4). With the addition of the new species, the genus *Proctoporus* contains 12 species from Peru; six of them (*Proctoporus guentheri*, *P. kiziriani*, *P. lacertus*, *P. machupicchu* sp. nov., *P. unsaacae*, *P. sucullucu*) located in the Department of Cusco.

Habitat and ecology: Individuals were found during the day under rocks in the montane forest, of the eastern slope, of the Cordillera Oriental of the Andes (Fig. 5).

Conservation: The status of this species is unknown. More herpetological surveys and population studies are needed to adequately assess its status.

Discussion

Similarities in morphology and coloration would place *P. machupicchu* closer to *P. guentheri* and *P. unsaacae*, but further incorporation of DNA sequences and morphological data should provide a better resolution to the position of this new species within *Proctoporus*. Although

the description of *P. machupicchu* represents an increase in the species richness within *Proctoporus*, the knowledge of the actual species diversity of the genus is still limited (Doan and Castoe 2003; Goicoechea et al. 2012) and some taxonomic problems still remain to be solved. Some authors (Goicoechea et al. 2012; Chávez et al. 2011; Köhler and Lehr 2004) have related Peruvian species of *Euspondylus* (*E. caideni* Köhler, *E. josyi* Köhler, *E. nellycarrillae* Köhler and Lehr, *E. oreades* Chávez, Siu-Ting, Durán, and Venegas, *E. rahmi* (De Grijis), *E. simonsii* Boulenger, and *E. spinalis* (Boulenger) with *Proctoporus*. These species are found along central and southern Peru, overlapping with the distribution of *Proctoporus* and share with *Proctoporus* several derived features including the presence of an undivided palpebral eye disc. Recently, Goicoechea et al. (2012) found molecular evidence to place a species of *Euspondylus*, *E. chasqui* within *Proctoporus*, nevertheless, the phylogenetic relationships of the remaining species of Peruvian *Euspondylus* and *Proctoporus* remains uncertain. On the other hand, an additional species of *Proctoporus*, *P. cephalolineatus*, presumably exist in Venezuela. This species was previously described as belonging to the *Proctoporus luctuosus* group (García-Perez and Yustiz, 1995). Nevertheless, because the holotype and unique specimen of this species has limbs that do not overlap when adpressed, Doan and Schargel (2003) removed *P. cephalolineatus* from the *P. luctuosus* group and related

Revised key to the genus *Proctoporus*

Key to the Species of *Proctoporus* from Perú, Bolivia, and Argentina (adapted from Goicoechea, Padial, Chaparro, Castroviejo-Fisher, and De la Riva 2013)

- 1a. Presence of prefrontals. 2
- 1b. Absence of prefrontal scales. 3
- 2a. Smooth dorsal scales, single large elongate subocular, presence of large spines at the base of the sulcus spermaticus *P. xestus*
- 2b. Keeled dorsal scales, several small subocular scales. *P. chasqui*
- 3a. Two pair of genial in contact. 5
- 3b. Three pair of genial in contact. 4
- 4a. Three supralabials anterior to the posteroventral angle of the subocular *P. iridescens*
- 4b. Four supralabials anterior to the posteroventral angle of the subocular. *P. machupicchu*
- 5a. Two to three supraoculars. 6
- 5b. Four supraoculars *P. pachyurus*
- 6a. Venter uniformly dark or with dark stippling or mottling near lateral scale rows. 7
- 6b. Venter clear yellow or orange without dark mottling. *P. guentheri*
- 7a. No continuous series of lateral ocelli. 8
- 7b. Continuous series of lateral ocelli. *P. unsaacae*
- 8a. Frontonasal scale longer than frontal scale. 9
- 8b. Frontonasal scale equal in length to frontal scale. 10
- 9a. Limbs overlapping when adpressed. *P. sucullucu*
- 9b. Limbs not overlapping when adpressed. *P. bolivianus*
- 10a. First supraocular not fused with first superciliary. 11
- 10b. First supraocular fused with first superciliary. *P. carabaya*
- 11a. Absence of loreal scale. *P. lacertus*
- 11b. Presence of loreal scale. *P. kiziriani*

this species with *Euspondylus* and *Pholidobolus* based on the presence of prefrontals in *P. cephalolineatus* (a character presumed not to be present in *Proctoporus* at this time). This species shows the presence of palpebral eye-disc divided vertically (J.E. García-Perez, pers. comm.). As the presence of an undivided palpebral eye disc is a diagnostic character for the genus *Proctoporus* (Doan and Castoe 2005; Goicoechea et al. 2012; 2013) we believe that this species does not belong to this genus. Further studies based on molecular and morphological data are necessary to cast some light on these topics, as well as on the relationships of *P. machupicchu* with other species in the genus.

Acknowledgments.—For allowing access to collections under their care, we are grateful to Percy Yanque and Rocío Orellana (MHNC), Carl J. Franklin (UTA), Robert P. Reynolds (USNM), and Darrel Frost (AMNH). We are indebted to the Curso Latinoamericano de Biología de la Conservación and the Asociación para la Conservación de la Cuenca Amazonica (ACCA) for support fieldwork. We are grateful to the Center for Conservation Education and Sustainability of the Smithsonian Conservation Biology Institute for providing laboratory equipment and to the rangers of the Historic Sanctuary of Machu Picchu for their invaluable contribution to field work. We would like to acknowledge José A. Ochoa for providing camera lucida in composing the ink pen illustrations in Fig. 2 A–F. We thank David Kizirian, Claudia Koch, Karen Wilke, and anonymous reviewers for their valuable comments to the manuscript, Javier Farfan for providing the pictures in Fig. 4, and Juan Elias García-Perez (MZ-UNELLEZ) for sharing data of the holotype (ULABG 3202) *Proctoporus cephalolineatus*. Noemí Goicoechea was supported by a FPI fellowship from the Spain Ministry of Science and Innovation. Collecting permits in Peru were issued by SERNANP-Machu Picchu (054-2012-SERNANP-JEF).

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Appendix 1

Specimens Examined. Museum acronyms refer to: AMNH, American Museum of Natural History, New York, USA; CBF, Colección Boliviana de Fauna, La Paz, Bolivia; MHNC, Museo de Historia Natural, Cusco, Peru; MNCN, Museo Nacional de Ciencias Naturales, Madrid, Spain; USNM, Smithsonian Institution, National Museum of Natural History, Washington, USA; UTA, University of Texas, Arlington, USA. Numbers in brackets represents the original field numbers.

Proctoporus bolivianus

PERU: Puno: Sandia (UTA 52946–47 [TMD 01267, TMD 01271]); Cuyo-Cuyo (MHNC5333 [MNCN 4532], MHNC 5348–49 [MNCN 4566, MNCN 4568], MNCN 43660–62 [MNCN 4531, MNCN 4534, MNCN 4567]); Patambuco (MHNC 5357 [MNCN 5357], MNCN 43663–64 [MNCN 4583, MNCN 4584]); BOLIVIA: La Paz: Pelechuco (MNCN 43655–56 [MNCN 4143, MNCN 4142]); Millipalla, 12 km S of Sorata (CBF 3437–39 [MNCN 4729, MNCN 4731, MNCN 4733], MNCN 43678–79 [MNCN 4730, MNCN 4732]); Charazani (CBF 2329 [MNCN 4159]); Caalaya (CBF 2330 [MNCN 4162]).

Proctoporus chasqui

PERU: Ayacucho: Road between Abra Tapuna and San Francisco (MNCN 44407–08 [MNCN 4830, MNCN 4831]).

Proctoporus carabaya

Perú: Puno: Carabaya (MHNC 5428 [holotype: MNCN 4709], MHNC 5429–31 [paratypes: MNC 4710, 4714, 4715]).

Proctoporus guentheri

PERU: Cusco: Urubamba (UTA 55366–67 [TMD 01322, TMD 01324]); Paucartambo (USNM 346179 [USNM 206266]); BOLIVIA: La Paz: Apolo (USNM 336148 [USNM 107286]).

Proctoporus iridescens

Perú: Puno: Sandia: Limbani (MHNC 5359 [holotype: MNCN 4590]), MHNC 5361 [paratype: MNCN 4593]); Puno: Carabaya (MHNC 5699, MHNC 5701 [paratypes: MNCN 4793, 4795]).

Proctoporus kiziriani

Perú: Cusco: Quispicanchi (MHNC 5366 [holotype: MNCN 4602]), MHNC 5680, MHNC 5682–83, MHNC 5685 [paratypes: MNCN 4750, 4751–4752, 4754]).

Proctoporus lacertus

PERU: La Convención: Tincochaca (USNM 49551 [holotype], 49552 [paratype]); Calca (UTA 55315–23 [TMD 01301, TMD 01307, TMD 01309, TMD 01310, TMD 01311, TMD 01312, TMD 01313, TMD 01316, TMD 01317], USNM 298685–90 [JEC 6264, JEC 6265, JEC 6266, JEC 6267, JEC 6268, JEC 6269]); Ollantaytambo (USNM 49549 [paratype], USNM 107649); Ñusta Hispana (USNM 60699); Torontoy (USNM 60726); Paucartambo (AMNH 142921 [AMNH11568]).

Proctoporus pachyurus

PERU: Junín: Cerro San Cristóbal (MHNC 4693–94 [TA504, TA505], MHNC 4696 [TA507]); Tarma (UTA 55267–72 [TMD 01211, 01213, TMD 01214, TMD 01215, TMD 01216, TMD 01220], UTA 55314 [TMD 01195]); Palca (USNM 299581–82 [JEC 7092, JEC 7093]).

Proctoporus sucullucu

PERU: Apurímac: Abancay (UTA 52950 [TMD 01146], UTA 55273–78 [TMD 01140, TMD 01141, TMD 01143, TMD 01144, TMD 01157, TMD 01159]); Cusco: Quillabamba (USNM 298632–33 [JEC 6093, JEC 6094]); Puno: Ollachea (USNM 299125–27 [JEC 6591, JEC 6592, JEC 6593]); Ayacucho, Anco (MNCN 44474–82 [MNCN 5012, MNCN 5013, MNCN 5014, MNCN 5015, MNCN 5016, MNCN 5017, MNCN 5018, MNCN 5019, MNCN 5020]).

Proctoporus unsaaca

PERU: Urubamba (UTA 55289–90 [TMD 01031, TMD 01032], UTA 55291–92 [TMD 01033, TMD 01035], UTA 55294–95 [TMD 01094, TMD 1037, TMD 01094]).

Proctoporus xestus

BOLIVIA: (AMNH 22740–41); Cochabamba (AMNH 38957–62).

A new species of Andean lizard *Proctoporus*



Luis Mamani graduated in Biological Sciences from Universidad Nacional de San Antonio Abad del Cusco in Perú. He received a bachelor degree in biology in 2013. He is currently an amphibian and reptile researcher at the Herpetological Collection of the Museum of Natural History, Universidad Nacional de San Antonio Abad del Cusco, Peru (MHNC). He has published a scientific paper in amphibian taxonomy and his interests include biodiversity, taxonomy, systematics, and biogeography of gymnophthalmid lizards.



Noemí Goicoechea earned her B.S. in Biology from Universidad Autonoma de Madrid, Spain, in 2007 and her M.S. in biodiversity and evolutionary biology from the same university in 2011. She is currently a Ph.D. student at the Museo Nacional de Ciencias Naturales (Madrid, Spain), where she is studying species diversity and diversification mechanisms in Andean lizards of the genera *Proctoporus* and *Liolaemus* within a phylogenetic and population genetic framework.



Juan Carlos Chaparro graduated in Biological Sciences from Universidad Nacional Pedro Ruiz Gallo, Lambayeque, Peru. He received a Master's degree in Biodiversity in Tropical Areas and Conservation in 2013, from a consortium between the International University of Menendez Pelayo (UIMP-Spain), Universidad Tecnológica Indoamerica (UTI-Ecuador), and Consejo Superior de Investigaciones Cientificas (CSIC-Spain), under the supervision of Dr. Ignacio de la Riva. He is currently curator and researcher of the Herpetological Collection of the Museum of Natural History, Universidad Nacional de San Antonio Abad del Cusco, Peru (MHNC). He has published more than 20 scientific papers, and two book chapters on taxonomy, biodiversity, systematics, phylogeny, conservation, and biogeography of South American amphibian and reptiles, with an emphasis on amphibians. He is interested in biodiversity, conservation, taxonomy, systematics, phylogeny, and biogeography of the neotropical herpetofauna.

In accordance with the International Code of Zoological Nomenclature new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in ZooBank (Polaszek 2005a, b), the official online registration system for the ICZN. The ZooBank publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix “<http://zoobank.org/>.” The LSID for this publication is: urn:lsid:zoobank.org:pub:ADEEE69A-964E-491F-93A8-EA7F4FE5303D.

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The most complete journal archiving and journal information is found at the official ARC journal website, amphibian-reptile-conservation.org. In addition, complete journal paper archiving is found at: ZenScientist, <http://www.zenscientist.com/index.php/filedrawer>.

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SHORT COMMUNICATION

***Noblella lynchi* Duellman 1991 (Anura: Craugastoridae): Geographic range extension, Peru**

¹Daniel Rodríguez

Universidad Nacional Mayor de San Marcos, Museo de Historia Natural, Departamento de Herpetología. Av. Arenales 1256, Jesús María, Ap. 14-0434, Lima, PERU

Abstract.—Reported is a significant range extension of the Leaf Litter Frog, *Noblella lynchi*, an endemic species to the Cordillera Central in northern Peru. The new record is in the Huiquilla Private Conservation Area.

Key words. Leaf Litter Frog, Huiquilla Private Conservation Area, Cordillera Central, Abra Chanchillo, district of Longuita, province of Luya, department of Amazonas, montane cloud forest

Citation: Rodríguez D. 2015. *Noblella lynchi* Duellman 1991 (Anura: Craugastoridae): Geographic range extension, Peru. *Amphibian & Reptile Conservation* 9(1) [Special Section]: 12–14 (e99).

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Noblella lynchi (Duellman 1991) is a leaf litter frog categorized as Data Deficient (DD) in the IUCN Red List, because little is known about the extent of its occurrence and ecological requirements (Amphibian Specialist Group 2013). The holotype of *Noblella lynchi* (KU 212318, female, SVL 20.2 mm) and the paratype (KU 212319, subadult female, SVL 16.2 mm) were collected on the slopes of Abra Chanchillo (06°49' S, 77°54' W, elevation 2,870 m asl), 42 km (by road) ENE of Balsas, province of Chachapoyas, department of Amazonas, Peru, obtained on 22 January 1989 by John J. Wiens (Duellman 1991).

During the course of fieldwork in the project “Estado de Conservación de anuros que habitan la Cuenca del Río Tingo en el Departamento de Amazonas” (Directorial Resolution N°033-2006-INRENA-IFFS-DCB), three specimens of *Noblella lynchi* were collected in a montane forest (06°23'10" S; 77°59'10.7" W, 2,700 m asl) in the Huiquilla Private Conservation Area (ACP Huiquilla), located in the district of Longuita, province of Luya, department of Amazonas by Daniel Rodríguez on 17 June 2006 (Fig. 1). The collected specimens were the following: MUSM 24885 is a male, SVL 15.3 mm; MUSM 24886 is a juvenile, SVL 7.8 mm, and MUSM 26448 is a female, SVL 19.5 mm) (Fig. 2).

The holotype and paratype of *Noblella lynchi* (KU 212318–19) were found at 2,870 m asl. Both specimens were under stones, during the day in cutover cloud forest. The type locality is along the road between Balsas and Leimebamba (Duellman 1991). The new specimens (MUSM 24885–86, 26448) were found at 2,700 m asl in leaf litter during the night in montane forest of high and low canopy (Young and León 1999). These specimens represent a northward extension of 49.1 kilometers and the first record for the province of Luya.

Currently, the species has some degree of protection, because it occurs in the ACP Huiquilla, which is an important fragment of the montane cloud forest in the northern part of the Cordillera Central.

Abbreviations: KU = Biodiversity Institute, University of Kansas, Lawrence, Kansas, USA; MUSM = Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Peru; SVL = snout-vent length; m = meters; asl = above sea level.

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Correspondence. Email: ¹daal911@yahoo.com

and Vanessa Correa. I also would like to thank Miguel Chocce for helping with the map and to José G. la Torre Montoya for access to ACP Huiquilla. Work was supported by the Asociación Peruana para la Conservación de la Naturaleza (APECO) and their research fund “María Koepcke.”

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Fig. 1. *Noblella lynchi* (A and B: male, MUSM 28216, SVL 24.8 mm; C and D: young, MUSM 24886, SVL 7.8 mm; E and F: female, MUSM 26448, SVL 19.5 mm). Photos by D. Rodríguez.

Range extension of *Noblella lynchi*

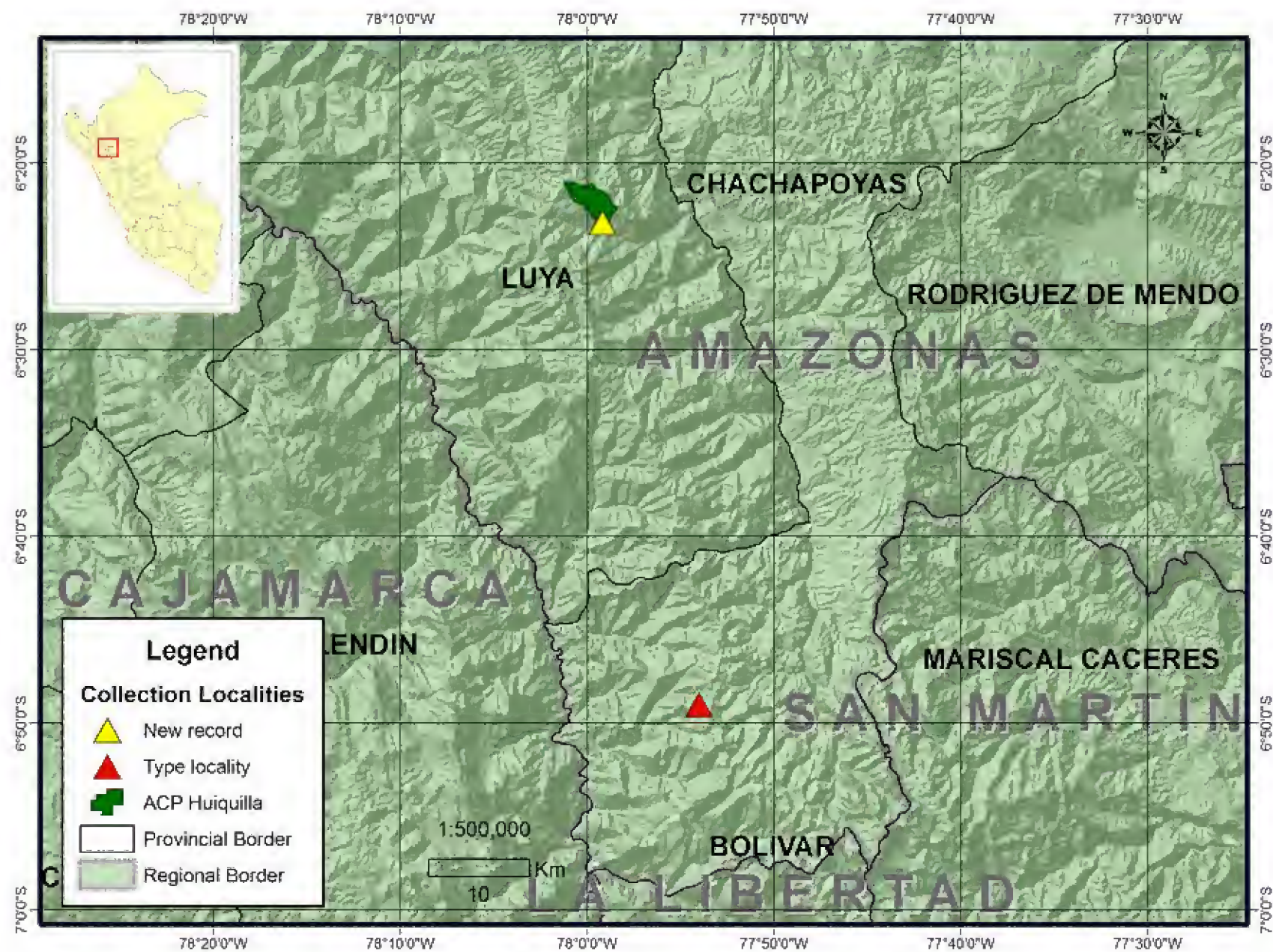
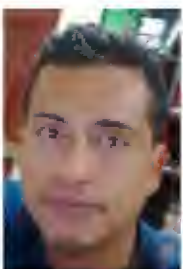


Fig. 2. Map showing distribution of *Noblella lynchi* in the Cordillera Central in northern Peru.



Daniel Rodríguez is a Peruvian biologist involved in the conservation of natural areas, amphibians, and reptiles. He is a researcher within the herpetology department at the Natural History Museum of San Marcos, Peru.



Two new species of frogs of the genus *Phrynopus* (Anura: Terrarana: Craugastoridae) from the Peruvian Andes

¹Germán Chávez, ²Roy Santa-Cruz, ³Daniel Rodriguez, and ⁴Edgar Lehr

¹División de Herpetología-Centro de Ornitología y Biodiversidad (CORBIDI), Santa Rita N°105 Of. 202, Urb. Huertos de San Antonio, Surco, Lima, PERU ²Museo de Historia Natural Universidad Nacional San Agustín, Arequipa, PERU ³Departamento de Herpetología, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos. Av. Arenales 1256, Lince, Lima 14, PERU ⁴Department of Biology, Illinois Wesleyan University, Bloomington, Illinois 61701, USA

Abstract.—We describe two new species of *Phrynopus* from the western and eastern Andes of northern and central Peru. One of them occurs in the Andean highlands of La Libertad region and is described from 20 specimens. This species can be differentiated from other *Phrynopus* species that lack a tympanum by the following combination of characters: skin of dorsum shagreen with scattered low tubercles; skin of venter smooth; no tubercles on upper eyelids; dentigerous process of vomers absent; vocal slits and nuptial pads absent; finger I slightly shorter than finger II; toe V slightly longer than toe III; and maximum SVL of females is 31.2 mm. The other species is described from three individuals found under moss-covered floors in the cloud forest of the Cordillera de Carpish, Huánuco region. It can be easily distinguished from other *Phrynopus* species by its vermilion red coloration on dorsum and venter.

Key words. Central Peru, Cordillera de Carpish, La Libertad, Huánuco, taxonomy

Resumen.— Describimos dos nuevas especies de *Phrynopus* de los Andes occidentales y de los Andes orientales del centro de Perú. Una de ellas es una especie de las zonas altoandinas de la región La Libertad, que puede ser diferenciada de las otras especies de *Phrynopus* que no tienen tímpano por una combinación única de caracteres que consiste en: piel del dorso granulada con presencia de tubérculos bajos desordenados; piel del vientre lisa; ausencia de tubérculos sobre los párpados; procesos vomerianos de los dientes ausentes; machos sin sacos vocales ni excrescencias nupciales; dedo I de la mano ligeramente más corto que el dedo II; dedo V del pie ligeramente más largo que el dedo III; longitud hocico-cloaca de hembras alcanza los 31.2 mm. La otra especie es descrita de tres individuos encontrados bajo el musgo del suelo en los bosques nublados de la Cordillera de Carpish, en la región de Huánuco que puede ser fácilmente diferenciada de las demás especies de *Phrynopus* por su coloración rojo bermellón, tanto en el dorso como en el vientre.

Palabras clave. Centro de Perú, Cordillera de Carpish La Libertad, Huanuco, taxonomía

Citation: Chávez G, Santa-Cruz R, Rodriguez D, Lehr E. 2015. Two new species of frogs of the genus *Phrynopus* (Anura: Terrarana: Craugastoridae) from the Peruvian Andes. *Amphibian & Reptile Conservation* 9(1) [Special Section]: 15–25 (e105).

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Introduction

Systematics of the frog genus *Phrynopus* were until recently poorly known. Over the last seven years this taxa was recognized as members of the family Craugastoridae (Hedges et al. 2008; Pyron and Wiens 2011; Padial et al. 2014), and placed into the taxon Holoadeninae (genera

Bryophryne, *Lynchi*, *Noblella*, *Psychophrynella*, and *Oreobates*; Padial et al. 2014).

The Andes of Peru hold a rich fauna of the genus *Phrynopus*. For instance, from a total of 26 species, 22 have been described from 2000 to 2015 (AmphibiaWeb 2015). Remarkably, central Peru has the highest diversity of this genus (Duellman and Lehr 2009; Lehr et al. 2000;

Correspondence. Emails: ¹vampflack@yahoo.com (Corresponding author); ²chara53@hotmail.com; ³daal911@yahoo.com; ⁴elehr@iwu.edu

Lehr 2002; Lehr et al. 2002; Lehr and Aguilar 2003; Lehr et al. 2005; Lehr and Oroz 2012; Mamani and Malqui 2014) with 25 species occurring in the Huánuco, Pasco, and Junín regions. *Phrynopus thompsoni* from La Libertad region currently marks the northernmost distribution of the genus. All species of *Phrynopus* are restricted to cloud forests and puna regions from 2,200 to 4,400 meters (m) of elevation (Duellman and Lehr 2009). During 2013 and 2014, fieldwork in the Andean highlands of La Libertad region (northwestern Peru) and cloud forests of the Huanuco region (Cordillera de Carpish, central Peru) revealed two new species of *Phrynopus*, which are described herein.

Material and Methods

Format of description follow Lynch and Duellman (1997) and character definitions defined in Duellman and Lehr (2009). We used preserved specimens (Appendix) and original species descriptions for the comparative diagnoses. Specimens were preserved in 96% ethanol and permanently stored in 70%. The following variables were

measured to the nearest 0.1 mm with digital calipers under a microscope: snout-vent length (SVL), tibia length (TL), foot length (FL, distance from proximal margin of inner metatarsal tubercle to tip of toe IV), head length (HL, from angle of jaw to tip of snout), head width (HW, at level of angle of jaw), eye diameter (ED), interorbital distance (IOD), upper eyelid width (EW), internarial distance (IND), eye-nostril distance, and (E-N, straight line distance between anterior corner of orbit and posterior margin of external nares). Fingers and toes numbered preaxially to postaxially from I–IV and I–V respectively. We determined comparative lengths of toes III and V by adpressing both toes against toe IV; lengths of fingers I and II were determined by adpressing the fingers against each other. Specimens were sexed based on external sexual characteristics (e.g., presence of vocal sacs) or through dissections to evaluation of gonads. To reduce reflections, preserved holotypes were photographed submersed in ethanol. Photographs taken in the field by the authors were used for descriptions of color in life. Specimens were deposited in the herpetological collection of the Centro de Ornitología y Biodiversidad (CORBIDI), Lima, Museo de Historia Natural Universidad

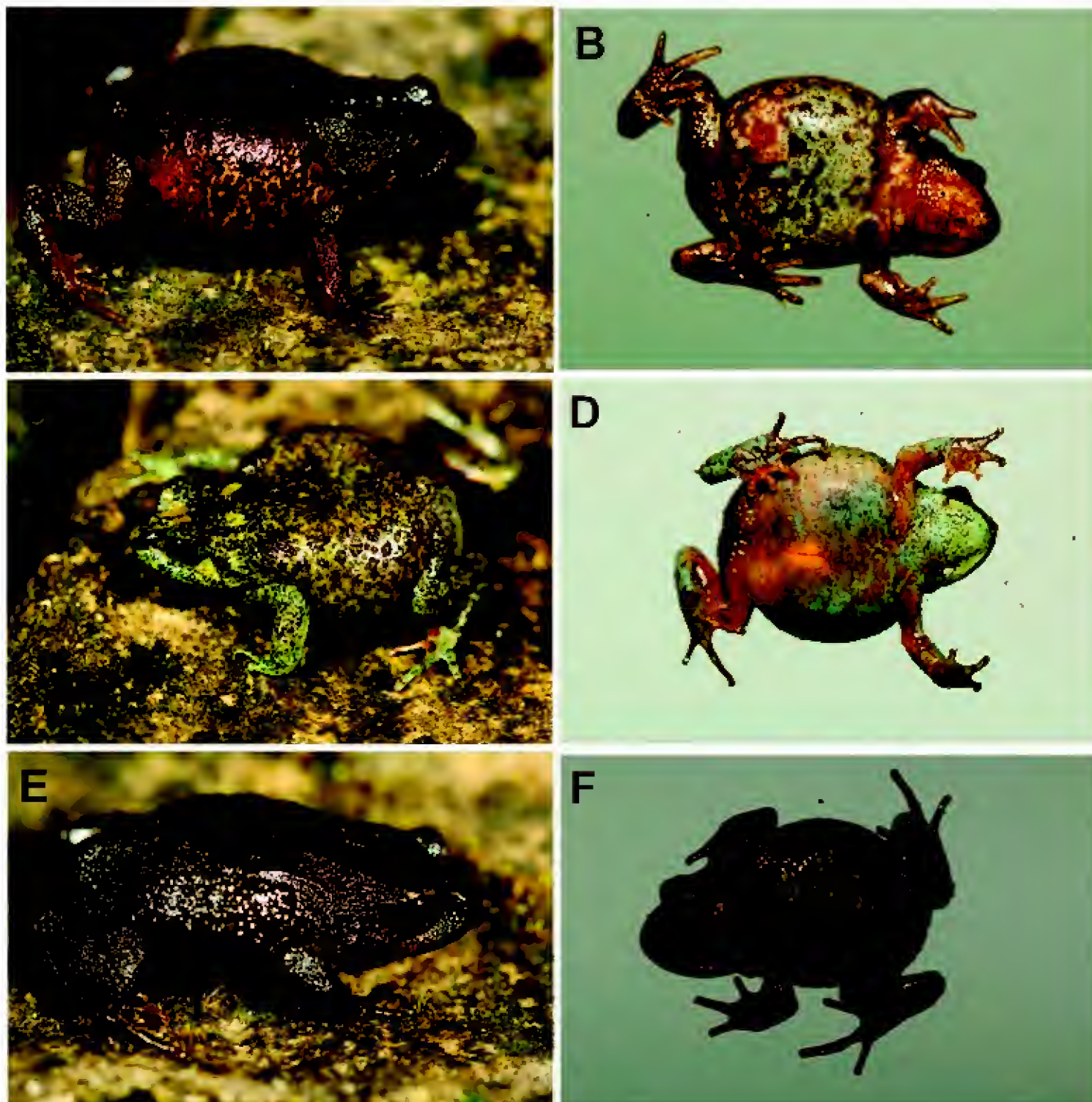


Fig. 1. Dorsal (left) and ventral (right) views of specimens of the type series of *Phrynopus valquii* sp. nov.: A–B) Holotype (CORBIDI 14005, adult female, SVL = 31.2 mm); C–D) Paratype (CORBIDI 14007, adult female, SVL = 28.07 mm); E–F (CORBIDI 13993, adult male, SVL = 25.2 mm). Photographs by Germán Chávez.

Nacional de San Marcos (MUSM), Lima, and Museo de Historia Natural de la Universidad Nacional San Agustín (MUSA), Arequipa, all in Peru. For specimens examined see Appendix I.

Results

Phrynopus valquii sp. nov.

urn:lsid:zoobank.org:act:77C37E4F-4FC2-42DE-8105-E1A834169142

Holotype: CORBIDI 14005 (Figs. 1–2), an adult female from “Cerro Alto Chucaro” (8° 3’0.60”S, 77°24’9.24”W) 4,025 m.a.s.l., Distrito de Parcoy, Provincia de Pataz, La Libertad region, Peru, collected on 26 February 2014 by Germán Chávez.

Paratypes: CORBIDI 13998–14001, 14003–04, 14006, and 14008 adult males and CORBIDI 14007 adult female, same data as holotype; CORBIDI 13989–94, 13996–97, adult males and CORBIDI 13988 and, 13995, adult females, collected two km southern of “Cerro Mush Mush” (8°4’12.08”S, 77°25’33.94”W) 4,123 m.a.s.l., Distrito de Parcoy, Provincia de Pataz, La Libertad region, Peru, on 27 February 2014 by Germán Chávez.

Diagnosis: A species of *Phrynopus* having the following combination of characters: (1) skin on dorsum shagreen with low scattered tubercles, skin on flanks areolate, skin on throat, chest and belly smooth, ventral surface of thighs coarsely areolate; discoidal and thoracic fold absent; dorsolateral folds absent; (2) tympanic membrane and tympanic annulus absent, supratympanic fold absent; (3) snout rounded in dorsal and lateral views; (4) upper

eyelid without conical tubercles; width of upper eyelid narrower than IOD; cranial crests absent; (5) dentigerous processes of vomers absent; (6) males lacking vocal slits and nuptial pads; (7) finger I slightly shorter than finger II; tips of digits rounded; (8) fingers without lateral fringes; (9) ulnar and tarsal tubercles absent; (10) heels lacking tubercles; inner tarsal fold absent; (11) inner metatarsal tubercle ovoid, about 1.5 times larger as rounded outer metatarsal tubercle; supernumerary plantar tubercles absent; (12) toes without lateral fringes; basal webbing present; toe V slightly longer than toe III; toe tips rounded, about as large as those on fingers; (13) in life, dorsum dark brown, reddish brown or olive green with irregular darker blotches, dark brown post orbital stripe present; throat cream, pearly white, pale salmon or creamy yellow, chest and belly creamy white or bluish white with or without brown irregular blotches; ventral surfaces of forearms and thighs brown or salmon, ventral surface of hands and feet cream or dark brown with irregular creamy white flecks or blotches; groin dark brown, or reddish brown with pearly white flecks; (14) SVL in females 26.4–31.2 mm ($n = 4$), in males 14.9–16.5 mm ($n = 16$).

The assignment of the new species to *Phrynopus* is based on the structure of the digital discs that lack circumferential grooves as well as the overall morphological similarity with other members of the genus. *Phrynopus valquii* shares the absence of tympanic annulus and tympanic membrane with most species except *P. auriculatus*, *P. montium* (tympanic annulus visible beneath skin), and *P. peruanus*. The only other species of *Phrynopus* known from La Libertad region is *P. thompsoni*, which inhabits mountains of western Andes, approximately 123 km from known localities of *P. valquii*. The following characters

Table 1. Range of measured characters (mm) and proportions of the type series of *Phrynopus valquii* and *P. daemon*. Range of measured characters is followed by mean and standard deviation in parentheses.

	<i>Phrynopus valquii</i>		<i>Phrynopus daemon</i>	
	Males ($n = 16$)	Females ($n = 4$)	Male ($n = 1$)	Females ($n = 2$)
SVL	21.02–26.45 ($\bar{x} = 23.59 \pm 1.34$)	26.48–31.21 ($\bar{x} = 28.89 \pm 2.05$)	21.7	21.42–24.35
HL	6.35–7.64 ($\bar{x} = 7.03 \pm 0.39$)	7.31–8.22 ($\bar{x} = 7.85 \pm 0.40$)	7.8	6.98–7.89
HW	7.56–8.72 ($\bar{x} = 8.15 \pm 0.39$)	8.89–9.84 ($\bar{x} = 9.43 \pm 0.41$)	7.6	8.02–8.08
TL	7.63–8.93 ($\bar{x} = 8.33 \pm 0.42$)	8.91–9.36 ($\bar{x} = 9.17 \pm 0.19$)	8.5	7.84–8.17
FL	8.53–10.44 ($\bar{x} = 9.48 \pm 0.63$)	10.13–10.86 ($\bar{x} = 10.43 \pm 0.30$)	9	7.98–9.61
ED	2.02–2.81 ($\bar{x} = 2.22 \pm 0.21$)	2.17–3.27 ($\bar{x} = 2.74 \pm 0.51$)	2.3	1.64–1.81
E-N	1.74–2.19 ($\bar{x} = 1.93 \pm 0.12$)	1.74–2.37 ($\bar{x} = 2.08 \pm 0.26$)	1.8	1.63–1.82
IOD	2.14–2.93 ($\bar{x} = 2.44 \pm 0.24$)	2.68–2.91 ($\bar{x} = 2.78 \pm 0.10$)	2.6	2.59–2.64
EW	1.56–2.27 ($\bar{x} = 2.01 \pm 0.16$)	2.05–2.56 ($\bar{x} = 2.23 \pm 0.23$)	1.7	1.96–1.98
IND	1.72–2.35 ($\bar{x} = 2.02 \pm 0.18$)	2.05–2.61 ($\bar{x} = 2.36 \pm 0.23$)	1.9	1.94–2.06
HL/SVL	0.27–0.32 ($\bar{x} = 0.29 \pm 0.01$)	0.26–0.27 ($\bar{x} = 0.27 \pm 0.00$)	0.35	0.32–0.32
HW/SVL	0.33–0.38 ($\bar{x} = 0.34 \pm 0.01$)	0.31–0.33 ($\bar{x} = 0.32 \pm 0.00$)	0.35	0.33–0.37
TL/SVL	0.32–0.38 ($\bar{x} = 0.35 \pm 0.01$)	0.29–0.34 ($\bar{x} = 0.31 \pm 0.01$)	0.39	0.33–0.36
E-N/ED	0.61–1.08 ($\bar{x} = 0.87 \pm 0.10$)	0.55–1.00 ($\bar{x} = 0.78 \pm 0.22$)	0.78	0.99–1.00
EW/IOD	0.66–1.00 ($\bar{x} = 0.83 \pm 0.09$)	0.76–0.90 ($\bar{x} = 0.80 \pm 0.07$)	0.65	0.75–0.75

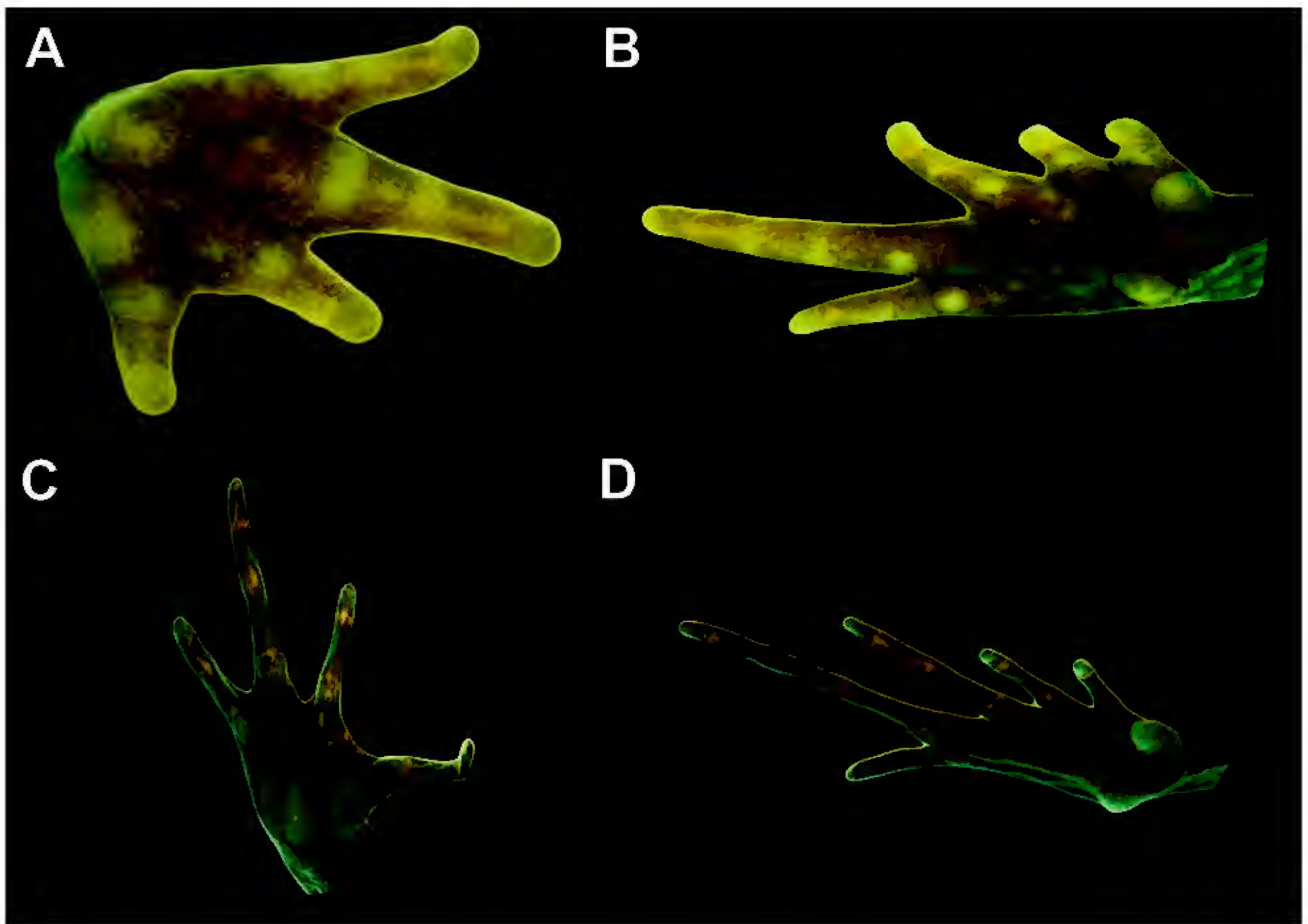


Fig. 2. Ventral view of: A) right hand of the holotype of *Phrynopus valquii*; B) right foot of the holotype of *Phrynopus valquii*; C) right hand of the holotype of *Phrynopus daemon*; D) right foot of the holotype of *Phrynopus daemon*. Photographs by Germán Chávez.

distinguish the two species: *P. valquii* lack pustules on skin of dorsum (*P. thompsoni* has skin on dorsum bearing pustules arranged in longitudinal rows), has smooth skin on venter (*P. thompsoni* has skin on venter coarsely areolate), finger I slightly shorter than finger II (*P. thompsoni* has fingers I and II of equal length), body size with a maximum SVL in females of 31.2 mm (*P. thompsoni* has a maximum SVL in females of 27.6 mm). Furthermore, *P. valquii* can be distinguished from its congeners which lack tympanic annulus and tympanic membrane by having skin on dorsum shagreen with scattered low tubercles (vs coarsely tuberculate in *P. barthlenae*, *P. chaparroi*, and *P. mirosławae*; smooth in *P. kauneorum*, *P. nicolae*, *P. oblivius*, and *P. tautzorum*; bearing conical or elongated tubercles, wart or ridges in *P. badius*, *P. bracki*, *P. bufoides*, *P. curator*, *P. nicolae*, *P. paucari*, *P. vestigiatus*, and *P. daemon* sp. nov.); skin on throat, chest, and belly smooth (vs weakly areolate in *P. badius*, *P. curator*, *P. interstinctus*, *P. lechriorynchus*, and *P. oblivius*; areolate in *P. barthlenae*, *P. bufoides*, *P. chaparroi*, *P. dagmarae*, *P. heimorum*, *P. horstpauli*, *P. kotosh*, *P. mirosławae*, *P. nicolae*, *P. paucari*, *P. pesantesi*, *P. tautzorum*, and *P. vestigiatus*; coarsely areolate in *P. daemon* sp. nov.); dorso-lateral folds absent (vs present in *P. daemon* sp. nov., *P. dagmarae*, *P. horstpauli*, *P. interstinctus*, *P. kotosh*, *P.*

mirosławae, and *P. vestigiatus*); supratympanic fold absent (vs present in *P. kauneorum*); snout rounded in dorsal view (vs elongated in *P. lechriorynchus*; truncate in *P. vestigiatus*); tubercles on upper eyelid absent (vs present in *P. barthlenae* and *P. curator*); dentigerous processes of vomers absent (vs present in *P. bracki*, *P. dagmarae*, *P. kauneorum*, *P. kotosh*, *P. lechriorynchus*, and *P. nicolae*; and minute in *P. interstinctus* and *P. vestigiatus*); nuptial pads absent (vs present in *P. barthlenae* and *P. chaparroi*); finger I slightly shorter than finger II (vs finger I much shorter than finger II in *P. dagmarae* and *P. horstpauli*; equal length in *P. juninensis*; finger I longer than finger II in *P. daemon* sp. nov.); lateral fringes on fingers and toes absent (vs present in *P. dagmarae*, *P. barthlenae*, and *P. vestigiatus*; and narrow lateral fringes present on fingers in *P. bracki*); ulnar tubercles absent (vs present in *P. kotosh*); tarsal fold absent (vs present in *P. lechriorynchus*); tubercles on heels absent (vs present in *P. badius*, *P. bracki*, *P. curator*, *P. dagmarae*, *P. horstpauli*, and *P. tribulosus*) and toe V slightly longer than toe III (vs toe V elongated, much longer than toe III in *P. bracki*, and *P. horstpauli*; equal length in *P. mirosławae*, *P. kotosh*, *P. tribulosus*, and *P. vestigiatus*; toe V slightly shorter than toe III in *P. heimorum*, *P. juninensis*, and *P. daemon* sp. nov.).

Description of Holotype (Fig. 1): Head narrower than body, wider than long, HW 119.7% of HL; HW 31.5% of SVL; HL 26.3% of SVL; snout short, rounded in dorsal and lateral views, (Fig. 1A), ED about as large as E-N distance; nostrils slightly protuberant, directed dorsolaterally; canthus rostralis short, straight in dorsal view, rounded in profile; loreal region slightly concave; lips rounded; upper eyelid without enlarged tubercles; EW narrower than IOD (EW 77.31% of IOD); tympanic region bearing rounded tubercles distinguishable in preservation; tympanic membrane and tympanic annulus absent; postictal tubercles present. Choanae small, ovoid, not concealed by palatal shelf of maxilla; dentigerous processes of vomers absent; tongue broad, slightly longer than wide, not notched posteriorly, posterior one half free. Skin on dorsum shagreen with small scattered tubercles, without dorsolateral folds; skin on flanks areolate; skin on throat, chest, and belly smooth; discoidal and thoracic folds present; cloacal sheath not discernible; large tubercles absent in cloacal region. Outer surface of forearm without minute tubercles; outer and inner palmar tubercles low, outer rounded, the same size of inner, rounded palmar tubercle; supernumerary tubercles absent, rounded, about half the size of subarticular tubercles; subarticular tubercles prominent, ovoid in dorsal view, rounded in lateral view, most prominent on base of fingers; fingers without lateral fringes; finger I slightly shorter than finger II; tips of digits rounded lacking marginal grooves (Fig. 2A). Hind limbs slender, short, TL

29.9% of SVL; FL 34.8% of SVL; upper surface of hind limbs shagreen with small, scattered tubercles; posterior and ventral surfaces of thighs coarsely areolate; heel without conical tubercles; outer surface of tarsus without tubercles; inner metatarsal tubercle ovoid, about one and a third times larger as rounded outer metatarsal tubercle; supernumerary plantar tubercles absent; subarticular tubercles low, ovoid in dorsal view; toes without lateral fringes; basal webbing present; toe tips rounded, lacking marginal grooves, about as large as those on fingers; relative lengths of toes: $1 < 2 < 3 < 5 < 4$; toe V slightly longer than toe III (Fig. 2B). Measurements (mm) of holotype: SVL 31.2; TL 9.3; FL 10.8; HL 8.2; HW 9.8; ED 2.4; IOD 2.9; EW 2.2; IND 2.4; E-N 2.3.

Coloration of holotype in life (Fig. 1): Dorsum reddish brown with small creamy white irregular flecks; postictal tubercles creamy white; dorsal surface of forearms reddish brown; canthal and supratympanic regions dark brown; flanks colored as dorsum, reddish brown with small creamy white irregular flecks; axilla and groin reddish brown (Fig. 1B); posterior surfaces of thighs and concealed surfaces of shanks reddish brown with pearly white blotches; throat pale salmon; chest, belly, and extremities (except ventral surfaces of hands and feet) bluish white with pale salmon irregular blotches; fingers and toes reddish brown, palmar and plantar surfaces and subarticular tubercles pale salmon; iris dark brown with creamy white reticulations.

Coloration of holotype in preservative: As described above with reddish brown coloration being dark brown and salmon coloration being creamy white; flanks dark brown; iris gray.

Variation: The males are smaller than the females and lack vocal slits and nuptial pads. The post-orbital stripe is absent in female CORBIDI 13988 and males CORBIDI 13997 and CORBIDI 14001, which have dorsal cream coloration with irregular weak brown blotches, and yellow blotches between the upper eyelids. Female CORBIDI 13988 bears tubercles on the upper eyelids and on the dorsum, where they are higher in the occipital region. Brown blotches on belly are present in most of individuals except in males CORBIDI 13998 and CORBIDI 13993 that have dark brown venter; CORBIDI 13998 has little white spots on the belly. Two males (CORBIDI 13989, 14008) have belly creamy white with weak brown irregular blotches. The color pattern of the ventral surfaces of thighs and forearms in female CORBIDI 13988 and male CORBIDI 14008 is salmon.

Etymology: The name is a patronym as tribute to Thomas Valqui, Ph.D. (Peru), ornithologist and founder of CORBIDI, in recognition of his valuable contributions and efforts for the conservation, research, and knowledge of Peruvian birds.

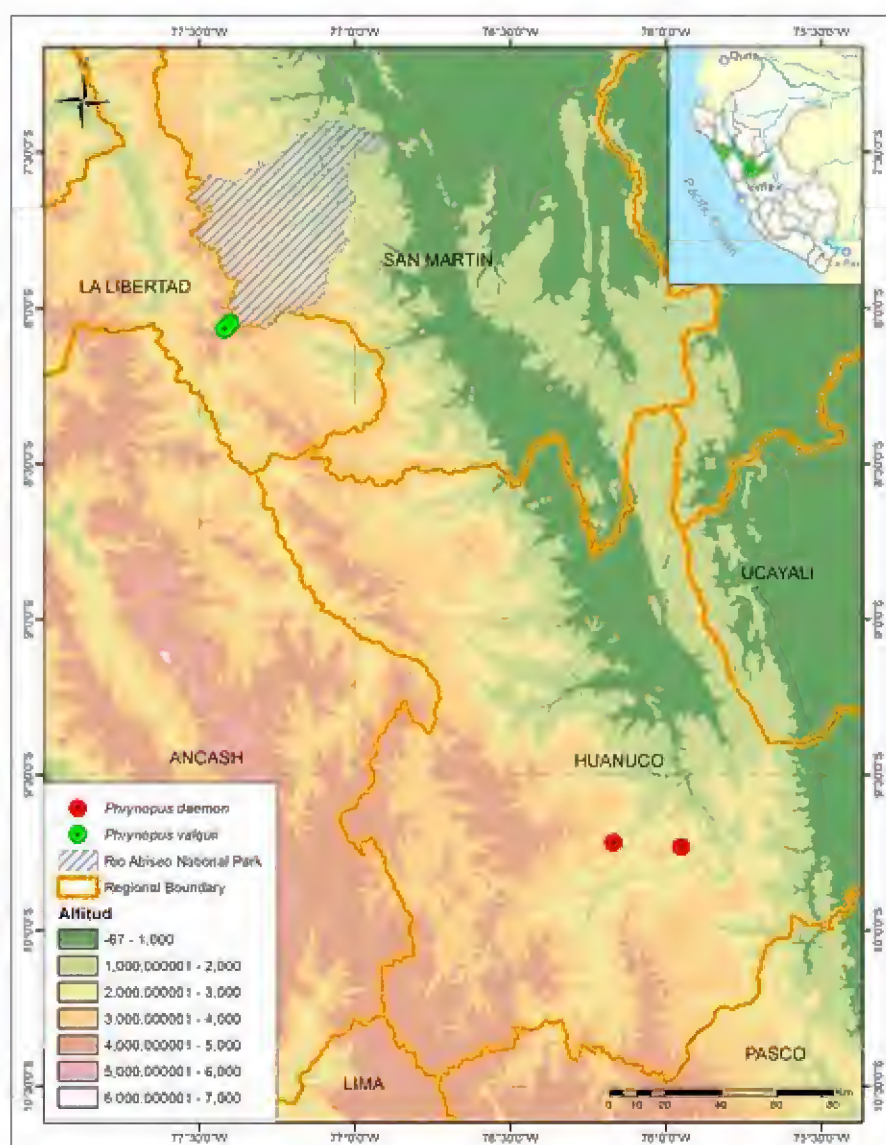


Fig. 3. Distribution of *Phrynopus valquii* sp. nov. (green circles) and *Phrynopus daemon* sp. nov. (red circles). Map by Caterina H. Cosmopolis.



Fig. 4. Dorsal (left) and ventral (right) views of the type series of *Phrynopus daemon* sp. nov.: A–B) Holotype (CORBIDI 15364, adult female, SVL = 24.3 mm); C–D) Female paratype (MUSA 4916, adult female, SVL = 21.4 mm); E–F) Male paratype (MUSM 32747, SVL = 21.7). Photographs: A–D by Roy Santa-Cruz and E–F by Daniel Rodríguez.

Distribution and Ecology: *Phrynopus valquii* is known from eastern Andes of La Libertad Region, two km far from southwestern limit of Rio Abiseo National Park (Fig. 3). All individuals were collected during the dry season, at daytime between 9:00 a.m. and 14:00 p.m in a flat and very humid grassland area surrounded by rocks clusters and mountains, under stones which form the dry bed of an old creek. The vegetation includes grasses of the families Poaceae and Valerianaceae, lichens and fungi growing on stone surfaces. The only sympatric anuran species recorded is *Gastrotheca phelloderma*.

Phrynopus daemon sp. nov.

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Holotype: CORBIDI 15364, (Figs. 2, 4A–B), an adult female, from Achupampa, Cordillera de Carpish (8°45'15.55"S, 76°34'39.03"W), 3,138 m.a.s.l., Distrito

de Chinchao, Provincia de Huánuco, Huánuco region, Peru, collected on 20 October 2014 by Roy Santa Cruz, Heidi Cardenas, Nelin Ramos, and Eduardo Crispin.

Paratypes: MUSA 4916 (Fig. 4 C–D), adult female, same data as holotype; MUSM 32747 (Fig. 4 E–F), an adult male from Unchog elfin forest, Cordillera de Carpish (09°43'1.93"S, 76°10'3.71"W), 3,341 m.a.s.l., Distrito de Churubamba, Provincia Huánuco, Huánuco region, Peru, collected on 20 July 2013 by Daniel Rodríguez.

Diagnosis: A species of *Phrynopus* having the following combination of characters: (1) skin on dorsum shagreen with small scattered tubercles, skin on flanks areolate, skin on throat, chest, belly and ventral surface of thighs areolate; thoracic fold evident; discoidal fold absent; fragmented dorsolateral folds present; (2) tym-

panic membrane and tympanic annulus absent, short supratympanic fold present; (3) snout rounded in dorsal view, subacuminate in lateral view; (4) upper eyelid without enlarged tubercles; width of upper eyelid narrower than IOD; cranial crests absent; (5) dentigerous processes of vomers absent; (6) vocal slits and nuptial pads absent, subgular vocal sac present; (7) finger I and II of equal length or finger I shorter than finger II; tips of digits rounded; (8) fingers with weak lateral fringes; (9) ulnar tubercles absent, low tarsal tubercles present; (10) heels lacking tubercles; inner tarsal fold absent; (11) inner metatarsal tubercle ovoid, about 1.5 times larger than rounded outer metatarsal tubercle; supernumerary plantar tubercles absent; (12) toes with lateral fringes; basal webbing absent; toe V slightly shorter than toe III; toe tips rounded, about as large as those of fingers; (13) in life, dorsum and flanks vermilion red or blackish brown; throat orange-red, chest, and belly vermilion red or blackish brown, ventral surface of hands and feet dark grey, iris green with fine black reticulations; (14) SVL in females 21.42–24.35 mm ($n = 2$), in single male 21.7 mm.

The assignment of the new species to *Phrynopus* is based on the structure of the digital discs lacking circumferential grooves, as well as the overall morphological similarity with the other members of the genus. *Phryno-*

pus daemon is readily distinguished from its congeners by its uniform red or blackish-brown coloration with an orange-red throat, and by its distinct fragmented dorso-lateral folds. *Phrynopus daemon* shares with nine other species of *Phrynopus* (*P. badius*, *P. bracki*, *P. dagmarae*, *P. heimorum*, *P. interstinctus*, *P. nicoleae*, *P. paucari*, *P. peruanus*, *P. vestigiatus*) coloration consisting of red in the groin. However, none of these species has a color combination consisting in the entire dorsum vermilion red or blackish brown and throat orange-red. Likewise, this species shares the absence of tympanic annulus and tympanic membrane with most species except *P. auriculatus*, *P. montium* (tympanic annulus visible beneath skin), and *P. peruanus*. Furthermore, *P. daemon* can be distinguished from the rest of its congeners by having skin on dorsum shagreen with scattered small tubercles (vs coarsely tuberculate in *P. barthlenae*, *P. chaparroi*, and *P. mirosławae*; smooth in *P. kauneorum*, *P. nicolae*, *P. obliivius*, and *P. tautzorum*; bearing conical, elongated, or low tubercles, warts or ridges in *P. badius*, *P. bracki*, *P. bufoides*, *P. curator*, *P. nicolae*, *P. paucari*, *P. thompsoni*, *P. vestigiatus*, and *P. valquii* sp. nov.); skin on throat, chest and belly areolate (vs weakly areolate in *P. badius*, *P. curator*, *P. interstinctus*, *P. lechriorynchus*, and *P. obliivius* and smooth in *P. bracki*, *P. juninensis*, *P. kauneorum*, *P. tribulosus*, and *P. valquii* sp. nov.); fragmented dorsolat-

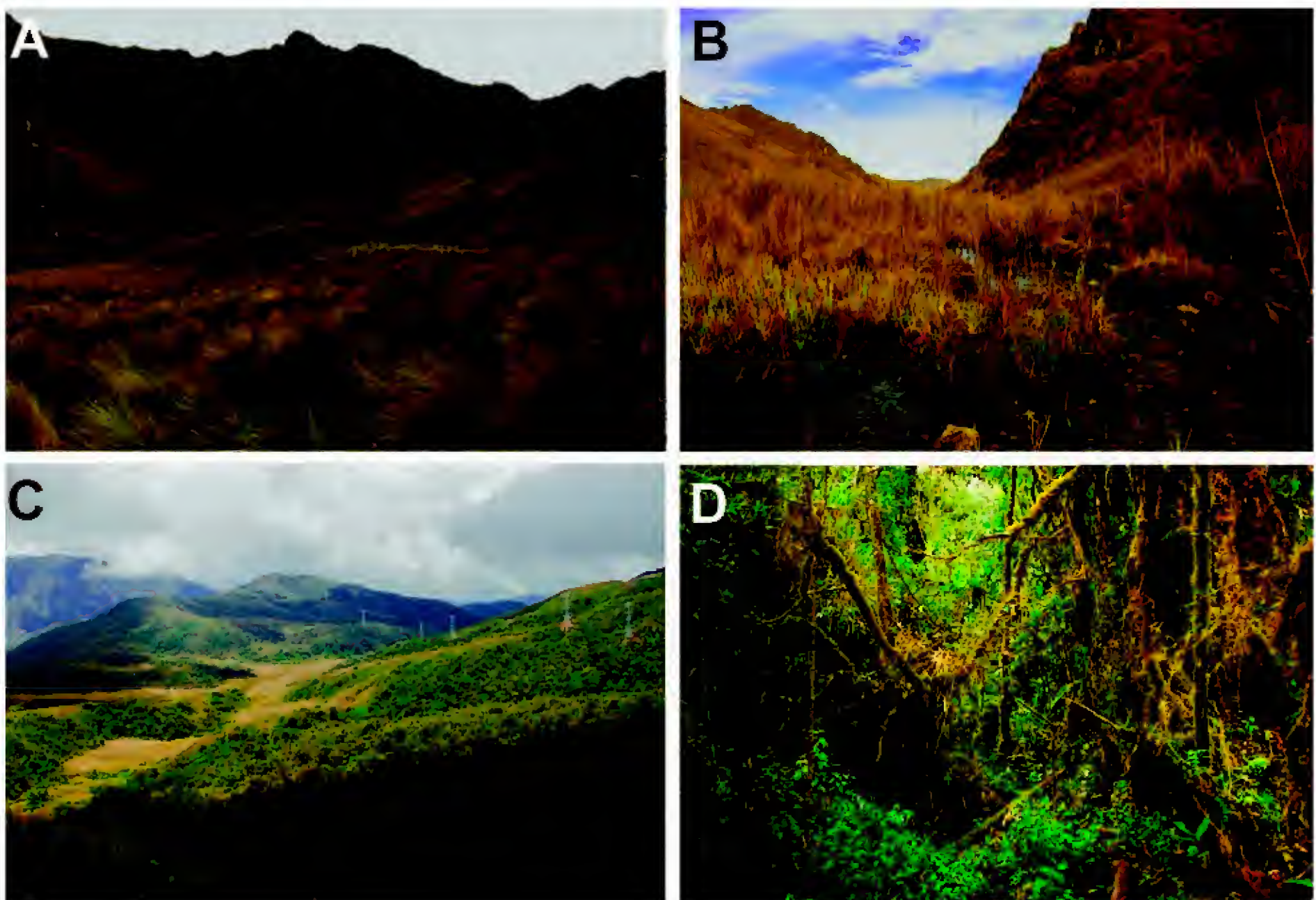


Fig. 5. A) Habitat of the type locality of *Phrynopus valquii* sp. nov.; B) Microhabitat of *Phrynopus valquii* sp. nov.; C) Habitat of the type locality of *Phrynopus daemon* sp. nov.; D) Microhabitat of *Phrynopus daemon* sp. nov. Photographs: A–B by Germán Chávez and C–D by Roy Santa-Cruz.

eral folds present (vs continuous dorsolateral folds present in *P. dagmarae*, *P. horstpauli*, *P. interstinctus*, *P. kotosh*, *P. mirosławae*, and *P. vestigiatus*); snout rounded from dorsal view (vs elongated in *P. lechriorynchus*; truncate from dorsal view in *P. vestigiatus*); tubercles on upper eyelid absent (vs present in *P. barthlenae* and *P. curator*); dentigerous processes of vomers absent (vs present in *P. bracki*, *P. dagmarae*, *P. horstpauli*, *P. kauneorum*, *P. kotosh*, *P. lechriorynchus*, and *P. nicolae*; minute in *P. interstinctus* and *P. vestigiatus*); lateral fringes on fingers absent (vs present in *P. dagmarae*, *P. barthlenae*, *P. thompsoni*, and *P. vestigiatus*; narrow lateral fringes present on fingers in *P. bracki*); ulnar tubercles absent (vs present in *P. kotosh*); tarsal fold absent (vs present in *P. lechriorynchus*); tubercles on heels absent (vs present in *P. badius*, *P. bracki*, *P. curator*, *P. dagmarae*, *P. horstpauli*, and *P. tribulosus*) and toe V slightly shorter than toe III (vs toe V elongated, much longer than toe III in *P. bracki* and *P. horstpauli*; of equal length in *P. kotosh*, *P. mirosławae*, *P. thompsoni*, *P. tribulosus*, and *P. vestigiatus*; toe V slightly longer than toe III in *P. bufoides*, *P. chaparroi*, *P. interstinctus*, *P. kauneorum*, *P. oblivius*, *P. paucari*, *P. pesantesi*, and *P. valquii* sp. nov.). Four other species of *Phrynopis* have been recorded from Cordillera de Carpi. Those are *P. dagmarae* (Lehr et al. 2002), *P. interstinctus* (Lehr and Oróz 2012, at San Marcos, 3,100–3,160 m), *P. kauneorum* (Lehr et al. 2002), and *P. vestigiatus* (Lehr and Oróz 2012, at San Pedro de Carpi, 3,100 m), but all of them can be differentiated from *P. daemon* sp. nov. by their different color pattern on dorsum, throat, and belly.

Description of the Holotype (Fig. 4 A–B): Head narrower than body, wider than long, HW 102.4% of HL; HW 33.2% of SVL; HL 32.4% of SVL; snout moderately short, rounded in dorsal view, sub acuminate in lateral view, (Fig. 4A), ED about as large as E–N distance; nostrils slightly protuberant, directed dorsolaterally; canthus rostralis short, straight in dorsal view, sub acuminate in profile; loreal region slightly concave; lips rounded; upper eyelid without enlarged tubercles; EW narrower than IOD (EW 68.9% of IOD); tympanic region lacking tubercles; tympanic membrane and tympanic annulus absent; postrectal tubercles absent. Choanae small, ovoid, not concealed by palatal shelf of maxilla; dentigerous processes of vomers absent; tongue broad, slightly longer than wide, not notched posteriorly, posterior one half free. Skin on dorsum shagreen with a few conical scattered tubercles, with ridges forming fragmented dorsolateral folds; skin on flanks coarsely areolate; skin on throat, chest, belly, and ventral surfaces of thighs coarsely areolate; thoracic fold present, discoidal fold absent; cloacal sheath not discernible; large tubercles absent in cloacal region. Outer surface of forearms with low tubercles; outer and inner palmar tubercles low, outer bilobate, the same size as inner, rounded palmar tubercle; supernumerary tubercles indistinct in preservative; subarticular

tubercles low, ovoid in dorsal view, most prominent on base of fingers; fingers without lateral fringes; finger I longer than finger II; tips of digits rounded lacking marginal grooves (Fig. 2C). Hind limbs slender, short, TL 33.5% of SVL; FL 39.4% of SVL; upper surface of hind limbs shagreen with scattered rounded tubercles; posterior and ventral surfaces of thighs coarsely areolate; heel without conical tubercles; outer surface of tarsus with low rounded tubercles; inner metatarsal tubercle ovoid, about one and a half times larger than rounded outer metatarsal tubercle; supernumerary plantar tubercles absent; subarticular tubercles low, ovoid in dorsal view; toes with lateral fringes; basal webbing absent; toe tips rounded, lacking marginal grooves, about as large as those of fingers; relative lengths of toes: $1 < 2 < 5 < 3 < 4$; toe V slightly shorter than toe III (Fig. 2D). Measurements (mm) of holotype: SVL 24.35; TL 8.17; FL 9.61; HL 7.89; HW 8.08; ED 1.81; IOD 2.64; EW 1.98; IND 2.06; E–N 1.82.

Coloration of holotype in life (Fig. 4 A–B): Dorsum, dorsal surface of forearms, canthal and supratympanic regions, flanks, axilla, and groin dark red (Fig. 4A); posterior surfaces of thighs and concealed surfaces of shanks of the same color as dorsum; throat, chest, belly, and ventral surfaces of forelimbs and hindlimbs red (Fig. 4B); fingers, toes, palmar, and plantar surfaces grayish black; iris bronze with fine black reticulations.

Coloration of holotype in preservative: As described above with dark red coloration being dark brown on dorsum and creamy white on venter and grayish black coloration being brown; iris gray.

Variation: Male MUSM 32747 has dorsal surfaces of head and body blackish brown, with vermilion red spots and black reticulations on dorsal surfaces of hind limbs, forelimbs and lateral surfaces of head and body; throat vermilion red, rest of ventral region is blackish brown. Dorsolateral ridges in this individual form fragmented dorsolateral folds (Fig. 3, E–F). Female paratype MUSA 4916 is smaller (SVL = 21.4) than the holotype, bearing higher tubercles on the dorsum; its dorsal color pattern is darker than the holotype, being the coloration of the belly and similar in all specimens.

Etymology: The specific name *daemon* is a latin word meaning “demon” in reference to the color pattern of the new species (red) which reminds the authors of the coloration attributed to the devil’s servants, ancestrally called demons.

Distribution and Ecology: *Phrynopis daemon* sp. nov. is known from two localities, in the Huanuco region (Fig. 3), central Peru. Both localities (Achupampa and Unchog forest) are located in the cloud forests of the Cordillera de Carpi, near the treeline on the eastern

side of the Andes. These cloud forests may be among the ecosystems most affected by new regimes of humidity and temperature caused by climate change, and by anthropogenic destruction (Gonzalez 2013). Individuals were collected during the dry season, at daytime, in very humid microhabitats. Females CORBIDI 15364 and MUSA 4916 were found on the ground underneath mosses and roots, at the transition between primary cloud forest and grassland, whereas male MUSM 32747 was found under a stone near a dry stream bed surrounded by a few bushes and trees. Sympatric amphibians recorded with the females are *Phrynopus dagmarae*, *P. horstpauli*, *Gastrotheca griswoldi*, and *G. stictopleura*, all of them more commonly observed than *P. daemon* sp. nov. Male MUSM 32747 was sympatric with two undescribed species of *Phrynopus*.

Discussion

The conservation status we propose for the two new species is based on IUCN's Red List criteria (cite IUCN Red List) and known distribution and threats. We consider plausible the occurrence of *Phrynopus valquii* inside Rio Abiseo National Park (RANP) because its type locality is approximately two km from the southwestern limit of this protected area, which covers more than 274,000 km²; part of this area contains grassland habitats and there are no geographical barriers between this limit and the type locality of *P. valquii*. Nevertheless, there are no confirmed records of the species inside the RANP, so we suggest to evaluate this species as Data Deficient based on the limited information about its distribution range and population status.

Phrynopus daemon inhabits cloud forests of the Cordillera de Carpish, which is located in the Cordillera Oriental (Atlantic drainage), Huánuco region. In this Cordillera recent herpetological surveys (over the last five years) have resulted in the discovery of five endemic species of *Phrynopus*: *P. dagmarae* Lehr, Aguilar, and Koehler 2001; *P. interstinctus* Lehr and Oroz 2012; *P. kauneorum* Lehr, Aguilar, and Koehler 2001, *P. vestigiatus* Lehr and Oroz 2012, and *P. daemon* sp. nov. Known distribution ranges include, for most of them, only a few localities. In fact, the Cordillera de Carpish is a chain of mountains located between the Chinchao and Derrepente rivers (both small tributaries of the Huallaga river, Huánuco region), that might promote endemism because of its varied topography and sharp altitudinal gradient passing from 600 m (at the bank of the Chinchao river) to 3,200 m of altitude over an airline distance of 28 km. Remarkably, this important Cordillera is not protected under Peruvian law, making it susceptible to deforestation by agriculture and timber extraction. Reduction in cloud forest cover is the main threat for *Phrynopus daemon* sp. nov. Furthermore, an interstate road which crosses Cordillera de Carpish (at both sides of Chinchao river)

and the developing of mining concessions in the area, add more threats to the conservation of the forests and their fauna. On the basis of a known distribution range smaller than 5,000 km², fragmentation of habitats near the type locality, and known threats from agriculture and mining, we suggest categorizing this species as Endangered (B1ab[ii,iii]) in the IUCN Red List.

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Appendix 1

Specimens examined:

- Phrynopus barthlenae*.—PERU: Huánuco: Maraypata (10°11'11.29"S, 76°05'58.4"W), 3,749 m: CORBIDI 14496–98.
- Phrynopus bracki*.—PERU: Pasco: Abra Esperanza, Parque Nacional Yanachaga Chemillén (10°31'57.40"S, 75°20'58.20"W), 2,808 m: CORBIDI 10302–10304, 2750, 11616, 11621, 11628, 11631.
- Phrynopus dagmarae*.—PERU: Huánuco: Palma Pampa, 3,020 m: MUSM 20451 (holotype). Achupampa, (09°43'48.87"S, 75°57'04.29"W), 3,122 m: CORBIDI 14552–59, 3,160 m: CORBIDI 14564–72, 14580–90.
- Phrynopus heimorum*.—PERU: Huánuco: ca. 10 km E Conchamarca, 3,240 m: MUSM 20441 (holotype).
- Phrynopus horstpauli*.—PERU: Huánuco: Sacsahuanca (10°12'50.01"S, 76°07'10.18"W), 3,472 m: CORBIDI 14539.
- Phrynopus interstinctus*.—PERU: Huánuco: Cordillera de Carpish, San Marcos, 3,100 m: MUSM 29543 (holotype), 3,160 m: MUSM 29544–29545 (paratypes).
- Phrynopus kauneorum*.—PERU: Huánuco: Camino Pampa Alegre-Ruinas de Huanacaure (09°45'29.07"S, 75°53'21.37"W), 2,996 m: CORBIDI 14591, 14594–95, 14615, 14629; Cordillera de Carpish, 2,735 m: MUSM 18585.
- Phrynopus peruanus*.—PERU: Junin: Puna of Maraynioc (11°21'35.2"S, 75°28'52.6"W), 3,825 m: MUSM 19977–78.
- Phrynopus tautzorum*.—PERU: Huánuco: Maraypata (10°09'13.45"S, 76°04'39.56"W), 3,949 m: CORBIDI 14504–05, 14507.
- Phrynopus tribulosus*.—PERU: Pasco: Abra Esperanza, Parque Nacional Yanachaga Chemillén (10°31'57.40"S, 75°20'58.20"W), 2,808 m: CORBIDI 10299–10301, 10°31'57.40"S, 75°20'57.02"W, 2,748 m, CORBIDI 11626, 11627, 11638.
- Phrynopus vestigiatus*.—PERU: Huanuco: Cordillera de Carpish, San Pedro de Carpish, 3,100 m: MUSM 29542 (holotype); Camino Pampa Alegre, Ruinas de Huanacaure (09°45'29.07"S, 75°53'21.37"W), 2,996 m: CORBIDI 14598–99, 14600–02, 14617–18.

Two new species of frogs of the genus *Phrynopus*



Germán Chávez is a Peruvian scientist working on the diversity and conservation of amphibians and reptiles in Peru since 2003. His research includes 16 scientific articles, describing four new species of reptiles, description of two new species of amphibians, and rediscovering an endemic frog from central Peru. Currently, he is an associated researcher at the Center of Ornithology and Biodiversity (CORBIDI) in Lima, Peru and is working on Andean amphibians and reptiles.



Roy Santa-Cruz has the bachelor degree in biology (2007). He is currently an amphibian and reptile researcher at the Herpetological Collection of the Museum of Natural History, Universidad Nacional de San Agustín de Arequipa, Perú (MUSA). His current research interests include taxonomy, biology, and ecology of amphibians and reptiles of Perú.



Daniel Rodríguez is a Peruvian biologist involved in the conservation of natural areas, amphibians, and reptiles. He is a researcher at the Herpetology Department of the Natural History Museum of San Marcos University, Lima, Perú.



Dr. Edgar Lehr is Associate Professor in the Department of Biology at Illinois Wesleyan University, USA. He serves as Associate Editor for both the *Journal of Herpetology* (SSAR) and *Salamandra* (DGHT). Lehr's research focuses on the amphibian and reptile diversity of Peru and has resulted in the publication of over 100 articles, two books, and the description of 84 new species (76 amphibians, eight reptiles) from Peru. Currently his research involves the herpetofauna of protected areas in central Andean Peru.

In accordance with the International Code of Zoological Nomenclature new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in ZooBank (Polaszek 2005a, b), the official online registration system for the ICZN. The ZooBank publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/." The LSID for this publication is: urn:lsid:zoobank.org:pub:833E0DC3-AFD3-4BA4-83EF-B738F386D415.

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A new elusive species of *Petracola* (Squamata: Gymnophthalmidae) from the Utcubamba basin in the Andes of northern Peru

¹Lourdes Y. Echevarría and ²Pablo J. Venegas

^{1,2}División de Herpetología-Centro de Ornitología y Biodiversidad (CORBIDI), Santa Rita N 105 36 Of. 202, Urb. Huertos de San Antonio, Surco, Lima, PERÚ ^{1,2}Museo de Zoología, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Avenida 12 de Octubre 1076 y Roca, Apartado 17-01-2184, Quito, ECUADOR

Abstract.—We described a new species of *Petracola* from the montane forests of the Utcubamba basin in Amazonas department, Andes of northern Peru (elevation 1,889 m). The new species is easily distinguishable from all other species of *Petracola* by having a gracile body, two supraoculars, one loreal scale, nine femoral pores per limb in males, and white venter with black semicircular marks on anterior margin of scales. An updated identification key for species of *Petracola* is provided.

Key words. Cordillera Central, Peruvian Yungas, *Petracola labioocularis*, precloacal pores, superciliaries, supraoculars

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Introduction

Modern molecular phylogenetic approaches sometimes combined with morphological data have revealed novel phylogenetic relationship for many groups of reptiles, viz.: South American pit viper genera *Bothrops*, *Bothriopsis*, and *Bothrocophias* by Fenwick et al. (2009); Teiidae lizards by Harvey et al. (2012); Jadin et al. (2013); and skinks by Hedges and Conn (2012). As in the aforementioned taxa, some important taxonomical changes were proposed for gymnophthalmid lizards by Doan and Castoe (2005), including the reallocation of *Proctoporus ventrimaculata* Boulenger 1900 in the genus *Petracola*.

The genus *Petracola* Doan and Castoe 2005 is a clade of small-sized Andean lizards with semifossorial habits occurring in cloud forest and puna habitats (Köhler and Lehr 2004; Kizirian et al. 2008). Three species endemic to Peru are currently recognized: *Petracola ventrimaculata* Boulenger 1900, known from multiple isolated localities between elevations of 3,050–3,600 m in the Andes of northern Peru, on both sides of the Marañón river (Kizirian et al. 2008); *P. labioocularis* Köhler and Lehr

2004, known only from the type locality at an elevation of 2,980 m in Central Peru; and *P. waka* Kizirian, Bayefsky-Anand, Eriksson, Le, and Donnelly 2008, known from four localities in Cajamarca department at elevations between 2,600 and 2,900 m.

In this paper, we describe a new species of *Petracola* based on morphological data from a single specimen, which was collected in 2007 in the Utcubamba basin of northeastern Peru. Subsequent visits by one of us (PJV) to the type locality of the taxon described herein, and other localities along the Utcubamba basin between 2012 and 2014, revealed no additional specimens of the new species. This discovery elevates the number of *Petracola* species to four species.

Materials and Methods

Museum abbreviations are Centro de Ornitología y Biodiversidad (CORBIDI) and Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM), both collections from Lima, Peru. The following measurements were taken with a digital caliper and recorded

Correspondence. Email: ¹lourdese.20@gmail.com (Corresponding author); ²sancarranca@yahoo.es

to the nearest 0.1 mm, except for tail length, which was taken with a ruler and recorded within 1 mm: head length (HL), head width (HW), shank length (ShL), axilla-groin distance (AGD), and snout-vent length (SVL). For characters recorded on both sides, condition on the right side is presented first. Sex was determined by observation of hemipenes from X-ray photographs. Scale counts and color pattern data for *P. labioocularis* were taken from Köhler and Lehr (2004) and some high quality photographs of an adult male paratype (SMF 80113) provided by G. Köhler. Data for *P. ventrimaculata* and *P. waka* was taken from Kizirian et al. (2008) and from examination of specimens of *P. ventrimaculata* (see Appendix 1). For comparisons with species of *Euspondylus*, *Pholidobolus*, *Proctoporus*, and *Riama* data was taken from Montanucci (1973), Kizirian (1996), and Doan and Castoe (2005). We follow the terminology of Kizirian (1996) for scale counts and morphological characters.

Results

Generic assignment

The new species is assigned to the genus *Petracola* as defined by Doan and Castoe (2005) having, among other characters, smooth head scales; transparent lower eyelid; rectangular, smooth, and juxtaposed dorsal scales; and

by lacking prefrontals. The morphological characters defining *Petracola* are similar to those of the genera *Euspondylus*, *Pholidobolus*, *Proctoporus*, and *Riama*. Thus, placement of this new species in the genus *Petracola* is tentative, based only on morphology and partly on distribution (see discussion below).

New species description

Petracola angustisoma sp. nov.

urn:lsid:zoobank.org:act:ED95BB48-4C31-4161-B4A2-EE4A787EDBD4

Holotype: CORBIDI 00467 (Figs. 1–3A), adult male from vicinity of Cocachimba (06°02'37.2"S, 77°53'15.8"W; Datum WGS 84) at 1,889 m, Bongará province, Amazonas department, Peru, collected by P.J. Venegas on 24 June 2007.

Diagnosis: *Petracola angustisoma* differs from *P. labioocularis* (character states in parentheses) in having two supraoculars (three), 37 transverse dorsal scale rows (34–35), 22 transverse ventral scale rows (18–20), dorsum pale brown with seven discontinuous dark brown longitudinal stripes extending to the base of tail (brown or olive brown with a dorsolateral pale stripe on neck and body), and venter white with black semicircular marks on anterior margin of scales (grayish brown, with no pattern); precloacal pores absent (present); and by lacking supralabial-subocular fusion (present). The new species can be distinguished from *P. ventrimaculata* by having a gracile body (robust, Fig. 3B), three discontinuous superciliaries (two), loreal present (usually absent), nine femoral pores per hind limb in males (2–5), and venter white with black semicircular marks on anterior margin of scales (yellow with bold black bands); from *P. waka* it differs in having three discontinuous superciliaries (four, usually continuous), two genials (three), and nine femoral pores per hind limb in males (5–7; Table 1).

Petracola angustisoma differs from all known species of *Euspondylus*, except *E. spinalis*, by lacking prefrontal scales and from *E. spinalis* by having two supraoculars (three in *E. spinalis*); from *Pholidobolus* by having dorsals smooth and juxtaposed (imbricate, striate, or keeled in *Pholidobolus*); from *Proctoporus* by having smooth dorsal scales (keeled in *Proctoporus*); and from *Riama* by having smooth dorsals (smooth, striate, rugose, or keeled in *Riama*).

Description of holotype: Rostral scale wider than long, taller than adjacent supralabials, in contact with frontonasal, nasals, and anteriormost supralabials. Frontonasal longer than wide, widest at level of nares, distinctly larger than frontal. Frontal approximately as long as wide, widest at anterior suture of anteriormost supraocular, barely extending between frontoparietals. Frontoparietals hexagonal, in contact medially and with

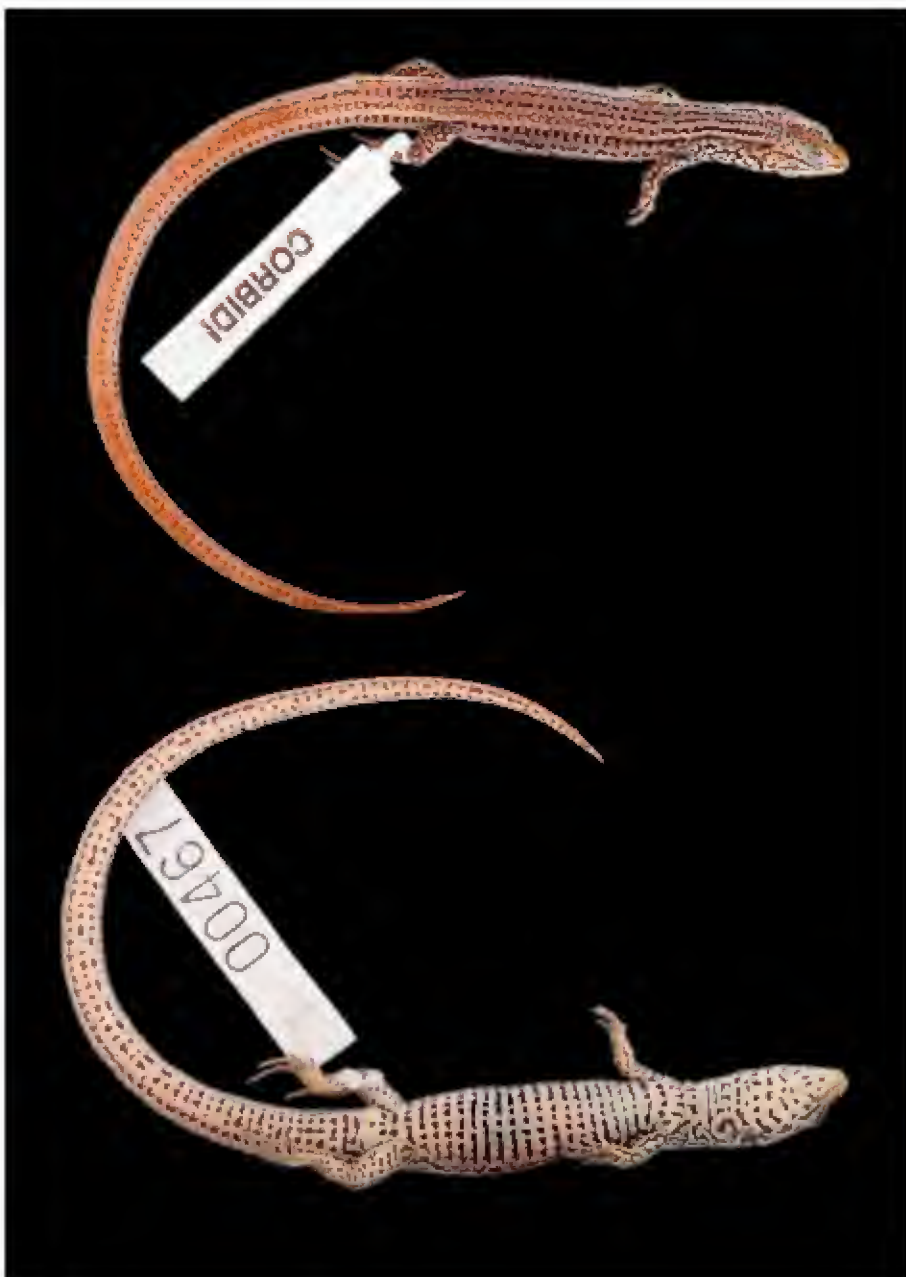


Fig. 1. *Petracola angustisoma* sp. nov., holotype CORBIDI 00467, male, 43.6 mm SVL. Dorsal (upper) and ventral (bottom) views. Photographs by D. Quirola.

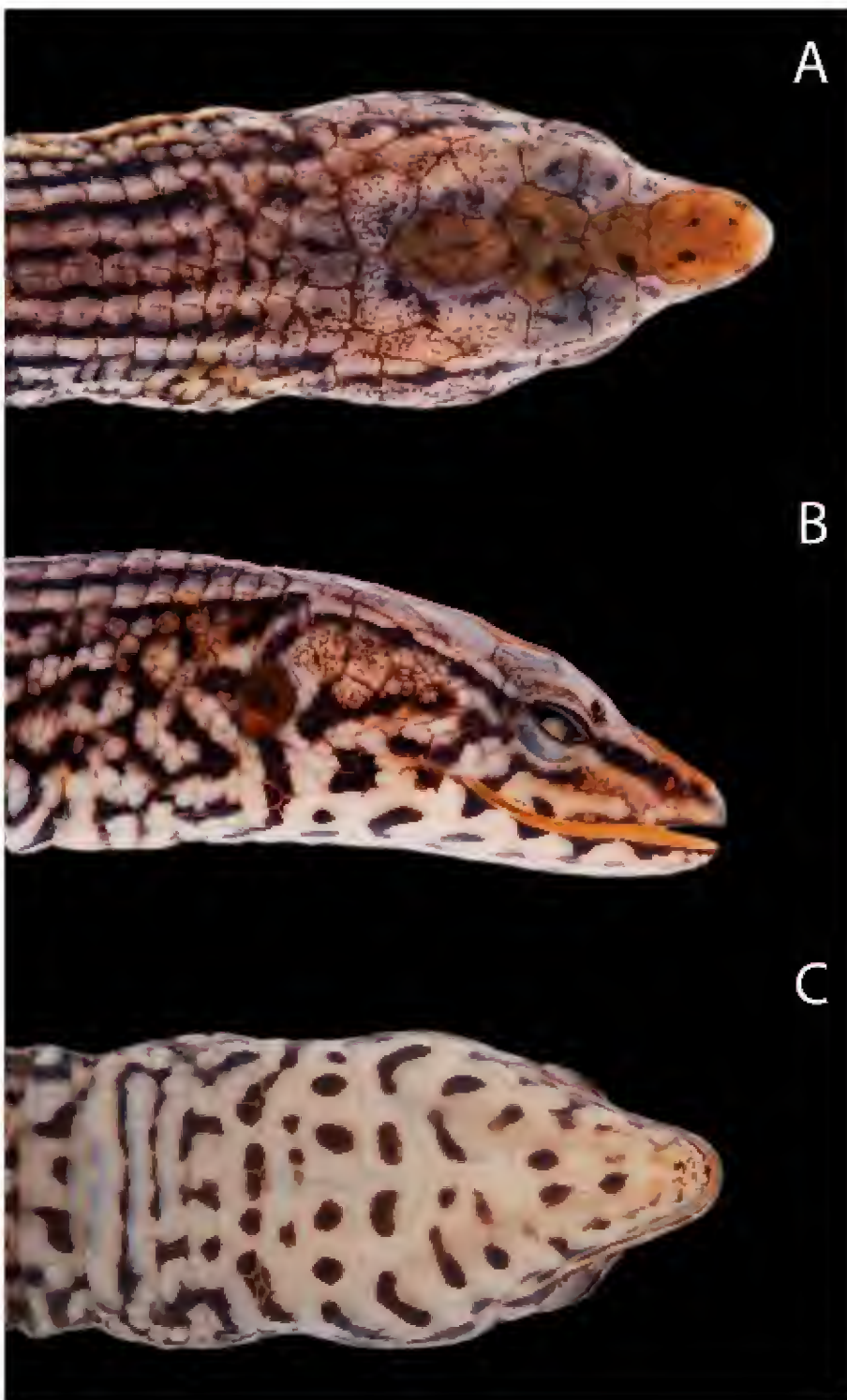


Fig. 2. Dorsal (A), lateral (B), and ventral (C) views of the head of *Petracola angustisoma* sp. nov. Holotype, CORBIDI 00467, male. Photographs by D. Quirola.

supraoculars. Interparietal hexagonal. Parietals polygonal, longer than wide. Postparietals two, with posterior sutures forming a nearly straight line. Supraoculars two. Anterior supraocular larger than posterior supraocular. Superciliary series discontinuous, 2–1/2–1, the anteriormost extending onto dorsal surface of head. Nape scales immediately posterior to head scales larger than adjacent dorsals. Nasal subtriangular, pierced in center by nostril, with shallow groove extending dorsally to loreal. One loreal on each side, not in contact with supralabials. Palpebral disc transparent with minute brown flecks. Supralabials eight. Suboculars three. Postoculars two. Supratympanic temporals 3/3. Tympanum recessed, transparent. Infralabials six. Genials two, meeting at broad midventral sutures. Pregulars in somewhat regular transverse rows, anteriormost two rows larger than posterior rows. Gulars in eight rows. Gular fold distinct, concealing three rows of small scales.

Dorsals smooth, juxtaposed, rectangular, in 37 transverse rows and 19 longitudinal rows (at tenth transverse ventral scale row). Ventrals smooth, in 22 transverse and 10 longitudinal rows. Dorsals and ventrals separated by



Fig. 3. Two species of *Petracola* in life. Holotype of *P. angustisoma* sp. nov. (A), and adult male of *P. ventrimaculata* (CORBIDI 03630) from Laguna Norte, Cajamarca (B). Photographs by P.J. Venegas.

approximately three longitudinal rows of small to granular scales, which are continuous with small to granular scales at insertion of limbs. Cloacal plate with two large anterior and four large posterior scales. Tail complete. Caudal scales rectangular, smooth, glossy, in 98 transverse rows.

Forelimbs pentadactyl, with claws. Anterodorsal scales smooth, glossy, polygonal, and larger than those on posterior side. Dorsal scales on brachium much larger than ventrals. Ventral scales on brachium subgranular. Anterior scales on antebrachium polygonal, smooth, and glossy. Posteroventral scales on antebrachium roundish, smooth, and glossy. Palmar scales domed, some with central pits. Dorsal scales on finger I 2/3, II 5/5, III 8/8, IV 10/9, and V 6/6. Subdigital lamellae undivided; on finger I 5/5, II 10/9, III 13/12, IV 13/13, and V 7/8.

Scales on anterior surface of thigh polygonal, smooth, glossy, and distinctly larger than adjacent scales. Scales on anteroventral surface of thigh polygonal smooth and glossy. Femoral pores 9/9. Scales on posterior surface of thigh small, round, smooth, and glossy. Scales on dorsal surface of crus polygonal to round, subimbricate, smooth, and glossy. Scales on ventral surface of crus significantly larger than adjacent scales. Scales on dorsal surface of foot polygonal, irregularly arranged, subimbricate, and of varying sizes. Dorsal scales on toe I 3/3, II 6/6, III 9/9, IV 12/12, V 7/7, and single. Plantar scales ovoid and domed. Subdigital lamellae divided from a point halfway

Table 1. Scutellational characters in species of *Petracola*. Range followed by mean ± standard deviation is given for quantitative characters if applicable.

Characters	<i>Petracola angustisoma</i> (<i>n</i> = 1)	<i>Petracola labioocularis</i>	<i>Petracola ventrimaculata</i> (<i>n</i> = 107)	<i>Petracola waka</i>
Supraoculars	2	3	2/2 (<i>n</i> = 106) 3/3 (<i>n</i> = 1)	2/2 (<i>n</i> = 35) 3/2 (<i>n</i> = 2) Other (<i>n</i> = 2)
Superciliaries	2–1/2–1	1–2/1–2	1–1/1–1 (<i>n</i> = 77) 2–1/2–1 (<i>n</i> = 8) 4/4 (<i>n</i> = 3) Other (<i>n</i> = 19)	4/4 (<i>n</i> = 32) 4/3 (<i>n</i> = 2) 5/4 (<i>n</i> = 1) 3/3 (<i>n</i> = 1) 2–1/2–1 (<i>n</i> = 1) 1–1/1–1 (<i>n</i> = 1) Other (<i>n</i> = 1)
Postoculars	2	2–3	2/2 (<i>n</i> = 103) Other (<i>n</i> = 4)	2/2 (<i>n</i> = 17) 3/3 (<i>n</i> = 14) 2/3 (<i>n</i> = 3) 3/2 (<i>n</i> = 4) Other (<i>n</i> = 1)
Loreals	1/1	0	0/0 (<i>n</i> = 97) 1/1 (<i>n</i> = 6) Other (<i>n</i> = 16)	2/2 (<i>n</i> = 5) 1/1 (<i>n</i> = 7) 2/1 (<i>n</i> = 1) 1/2 (<i>n</i> = 3) 0/0 (<i>n</i> = 1)
Supralabials	8	—	6/6 (<i>n</i> = 39) 7/7 (<i>n</i> = 34) 6/7 (<i>n</i> = 10) Other (<i>n</i> = 23)	8/8 (<i>n</i> = 14) 7/7 (<i>n</i> = 13) 8/7 (<i>n</i> = 6) 7/8 (<i>n</i> = 2) 7/6 (<i>n</i> = 2)
Infralabials	6	—	6/6 (<i>n</i> = 60) 7/6 (<i>n</i> = 11) 6/5 (<i>n</i> = 11) Other (<i>n</i> = 24)	7/7 (<i>n</i> = 14) 6/6 (<i>n</i> = 15) 5/6 (<i>n</i> = 2) 6/5 (<i>n</i> = 1) 8/7 (<i>n</i> = 1) 6/7 (<i>n</i> = 1) 5/5 (<i>n</i> = 1)
Genials	2/2	2–3 (2.7 ± 0.45)	2/2 (<i>n</i> = 103) 3/3 (<i>n</i> = 3) 3/2 (<i>n</i> = 1)	3/3 (<i>n</i> = 35)
Transverse dorsal scale rows	37	34–35 34.7 ± 0.45	30–41 34.24 ± 2.25 (<i>n</i> = 107)	36–49 (<i>n</i> = 39; 42.2 ± 4.16)
Longitudinal dorsal scale rows	19	—	15–23 18.71 ± 1.52 (<i>n</i> = 107)	—
Transverse ventral scale rows	22	18–20 19.2 ± 0.72	21.88 ± 1.43 (<i>n</i> = 106)	23–28 (<i>n</i> = 37; 25.0 ± 1.23)
Longitudinal ventral scale rows	10	10	8–13 10.82 ± 1.02 (<i>n</i> = 106)	—
Femoral pores per hind limb in males	9	10–11	2–5	5–7
Femoral pores per hind limb in females	—	0–3	0–6	0–4

between base and tip to the base of toes in 7/6 rows on toe I, 12/12 on II, 17/16 on III, 20/19 on IV, 11/13 on V. Measurements (mm) and proportions of the holotype: SVL 43.6 mm; TL 100 mm; HL 9.6; HW 6.7; ShL 5; AGD 23.4; TL/SVL 2.3; HL/SVL 0.2; HW/SVL 0.2; ShL/SVL 0.1; and AGD/SVL 0.5.

Holotype color in life: Dorsal background pale brown with seven discontinuous black longitudinal stripes on dorsum and two on flanks (continuous on neck) extending onto base of tail; dorsal and dorsolateral aspects with six longitudinal rows of dark yellow flecks extending onto tail; limbs covered by dark brown reticulations;

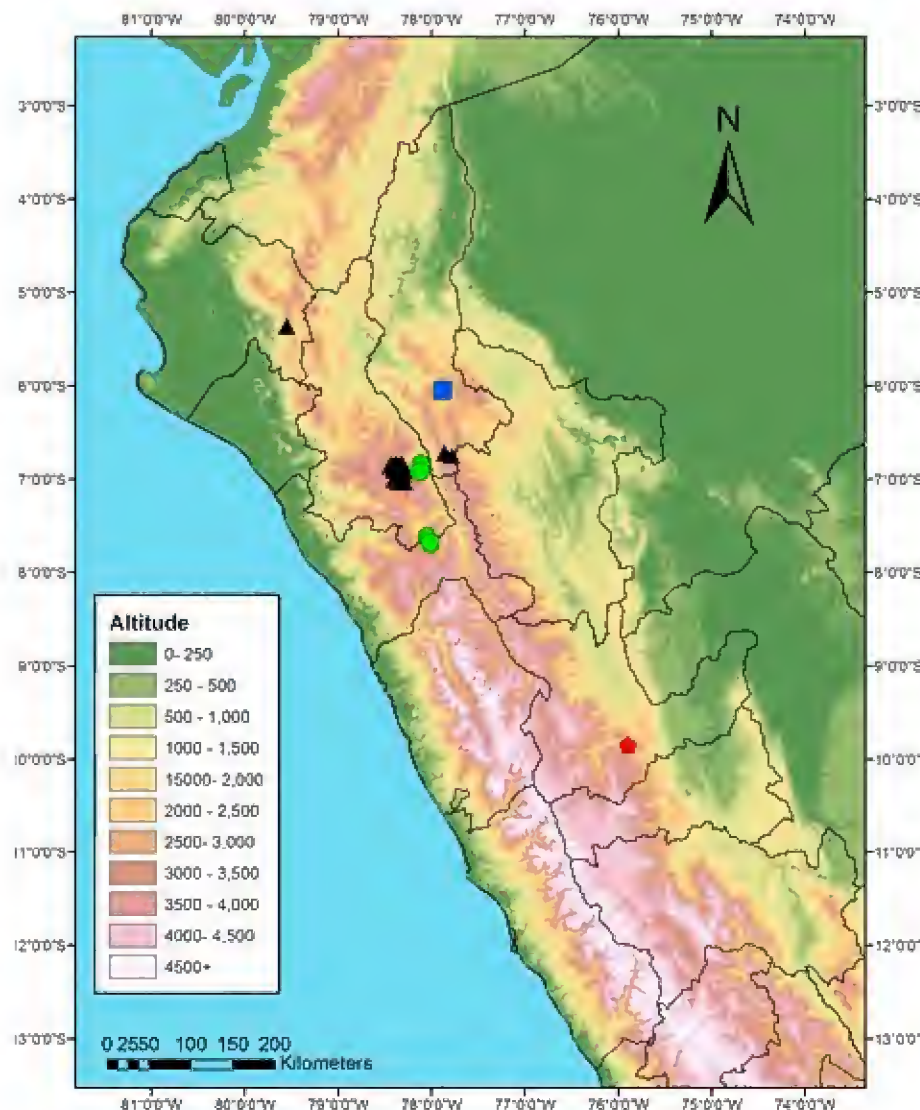


Fig. 4. Distribution map of species of *Petracola*. *Petracola angustisoma* sp. nov. (blue square), *P. ventrimaculata* (black triangles), *P. labioocularis* (red pentagon), *P. waka* (green circles).

tail with scattered dark brown marks; sides of head with longitudinal black stripes; labials and ventrolateral region of head white with black marks; sides of neck covered with black reticulations; and four faint ocelli with creamy brown center above the forelimb insertion (Fig. 3A). Ventral surface of body including limbs and tail white; ventral surface of head with irregular black marks on the center of each scale; ventral surface of neck with two transverse black stripes; ventral surface of trunk and tail with black semicircular marks on anterior margin of scales, arranged in transverse rows; ventral surface of forelimbs with black reticulations; ventral surface of hind limbs with roundish black marks.

Color in preservative: Similar to color in life but the dark yellow flecks on dorsum, dorsolateral region and tail are cream instead of dark yellow, and the center of the four ocelli above forelimb are cream instead of creamy brown (Fig. 1).

Distribution and natural history: The new species is known only from its type locality in a montane forest of the Utcubamba basin, northern portion of Cordillera Central, Peru, at 1,889 m (Fig. 4). Following the terrestrial ecoregions of the world by Olson et al. (2001), this locality lies in the Peruvian Yungas ecoregion. The holotype of *P. angustisoma* was found under a pile of decaying vegetation inside an abandoned house, along with a juvenile specimen of *Mastigodryas boddaerti*. The

type locality lies in the vicinity of Cocachimba and is composed of croplands with scattered large boulders and bushes, embedded in a matrix of humid montane forest. However, the forest has been almost completely removed and only some small patches of secondary forest remain close to ravines. Sympatric species of squamate reptiles are *Atractus* sp., *Chironius exoletus*, *M. boddaerti*, and *Stenocercus huancabambae*.

Etymology: The specific epithet *angustisoma* is a noun (in apposition) in the nominative singular and derives from the Latin words *angusti* (= narrow) and *soma* (= body). It refers to the slender body of this species.

Discussion

Although the practice of describing species with a single specimen is not recommended, we feel confident about the identity of *Petracola angustisoma* as a different taxon, due to its strikingly distinctive diagnostic characters. Unfortunately we were not able to collect additional specimens, despite repeated surveys to the type locality and other adjacent localities along the Utcubamba basin. The genus *Petracola* was erected by Doan and Castoe (2005) based on the results of a phylogenetic study of gymnophthalmid lizards using molecular evidence (Castoe et al. 2004), where samples of *Proctoporus ventrimaculata* (KU 219838) and *Proctoporus* cf. *ventrimaculata* (KU 212687) resulted paraphyletic to *Proctoporus* (see Fig. 6 in Castoe et al. 2004). Based on morphological evidence, the authors assigned *Proctoporus labioocularis* (Köhler and Lehr 2004), a species from central Peru (Fig. 4), to the genus *Petracola*. Three years later Kizirian et al. (2008) described *Petracola waka*, remarking that the new species allocation to the genera was based on convenience rather than confidence regarding phylogenetic relationships; however, they overlooked the fact that one of the paratypes of *P. waka* (KU 212687) was included in Castoe et al. (2004) phylogeny. Therefore, the assignment of this species to the genus *Petracola* is supported by molecular evidence as well.

The identification of superciliaries and supraoculars in gymnophthalmid lizards has not been consistent. Herein we follow the terminology of Kizirian (1996), who defines the superciliaries as those scales between the supraoculars and the ciliaries, in a continuous or discontinuous series, and in *Petracola ventrimaculata* the anteriormost supraocular is fused with the first superciliary. Doan and Castoe (2005) consider that *P. ventrimaculata* has three supraoculars and Köhler and Lehr (2004) consider that *P. labioocularis* has four supraoculars. Following Kizirian (1996), the anteriormost “supraocular” in both *P. ventrimaculata* and *P. labioocularis* is the first superciliary. Thus, *P. ventrimaculata* has two supraoculars and two discontinuous superciliaries, of which the anteriormost extends onto the dorsal surface of head (Uzzell 1970;

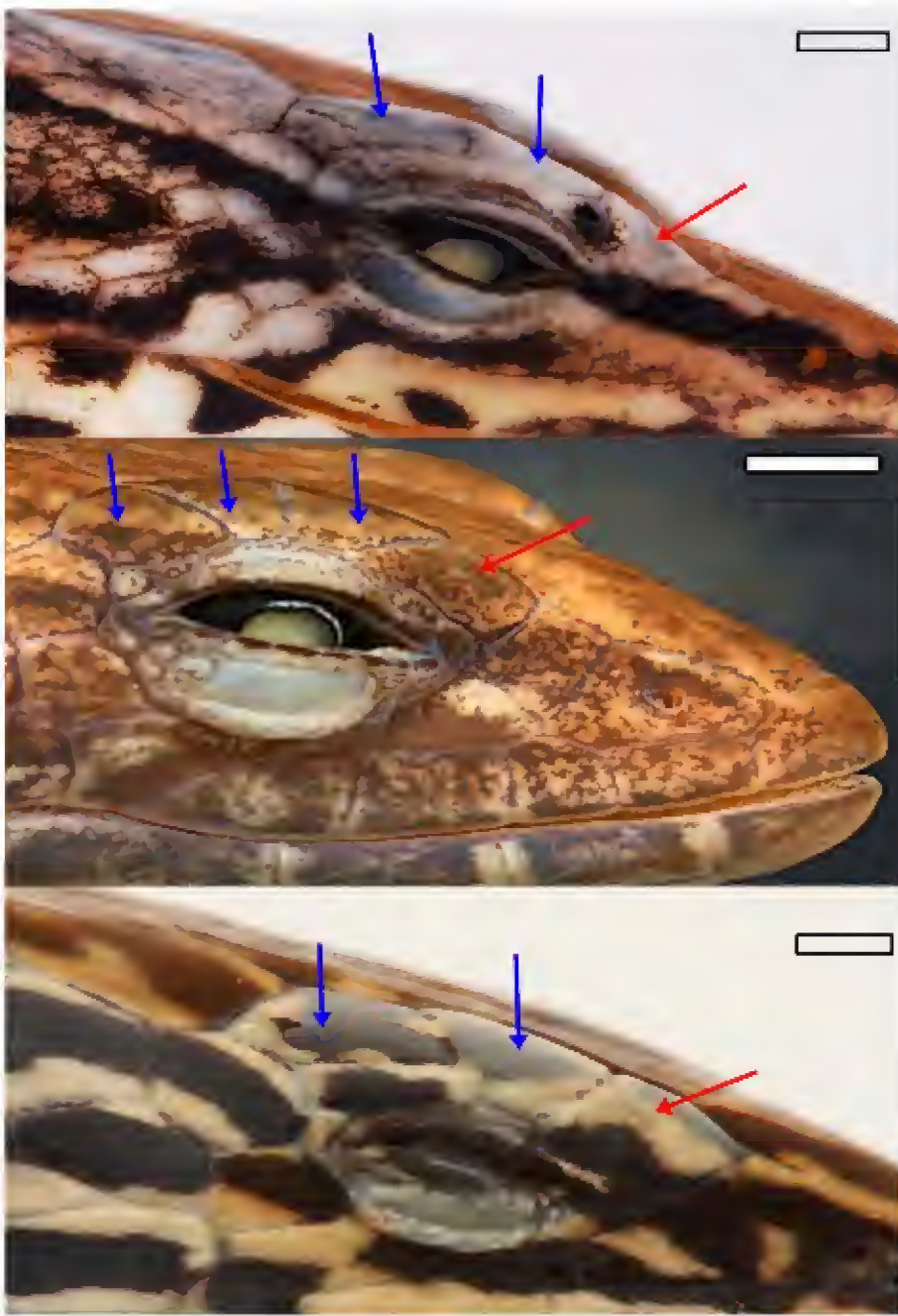


Fig. 5. Close-up of the heads of *Petracola angustisoma* sp. nov. (A), *P. labioocularis* (SMF 80113) (B), and *P. ventrimaculata* (CORBIDI 03630) (C), showing the anteriormost superciliary (red arrows) and supraoculars (blue arrows). Scale bar = 1 mm. Photographs by D. Quirola, G. Köhler, and J.C. Chavez, respectively.

Kizirian et al. 2008), a condition shared with *P. labioocularis*, *P. waka*, and the species described herein (Fig. 5).

We found conspicuous differences between *Petracola labioocularis* and all other species of *Petracola*, such as the presence of three supraoculars, supralabial-subocular fusion, and precloacal pores in males and females (or no scales between femoral pores; Fig. 6), a rare condition in Gymnophthalmidae, also present in some *Riama* species (Kizirian 1996). It also has a disjunct distribution being the only species of the genus present in central Peru which makes its allocation in the genus doubtful. We tentatively assigned the new species to the genus *Petracola* due to overall similarities with other species of

the genus, especially the presence of two supraoculars, anteriormost superciliary extended onto dorsal surface of head (or fused with anteriormost supraocular), and its distribution in the Andes of northern Peru (Fig. 4). Increased taxon sampling in a molecular phylogeny is needed to resolve the phylogenetic relationships among *Petracola angustisoma*, *P. labioocularis*, and other species currently recognized as *Petracola*.

Acknowledgments.—We are grateful to the staff of Asociacion Ecosistemas Andinos (ECOAN) and Consultores Asociados en Naturaleza y Desarrollo (CANDES) for their valuable help and logistic support in two different field trips. The authors are very grateful to Dr. G. Köhler for his kind willingness to cooperate with high quality photographs and information of *Petracola labioocularis*. We are also thankful to D. Quirola and J.C. Chavez for taking photographs of preserved specimens. Collecting permits were issued by the Instituto Nacional de Recursos Naturales (110-2007-INRENA-IFFS-DCB), Lima, Peru.

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Key to species of *Petracola*

- 1.a. Supralabial-subocular fusion and precloacal pores present.....*P. labioocularis*
- 1.b. Supralabial-subocular fusion and precloacal pores absent.....2
- 2.a. Superciliary series complete, genials three, and venter pale with scattered dark brown spots.....*P. waka*
- 2.b. Superciliary series incomplete, genials two, and venter pale with black bands or spots.....3
- 3.a. Loreal absent, 2–5 femoral pores per hind limb in males and venter pale with bold black transverse band.....*P. ventrimaculata*
- 3.b. Loreal present, nine femoral pores per hind limb in males and venter pale with transverse rows of black spots...*P. angustisoma*



Fig. 6. Ventral view of waist of *Petracola labioocularis* (paratype, SMF 80113) showing the precloacal and femoral pores. Scale bar = 1 mm. Photograph by G. Köhler.

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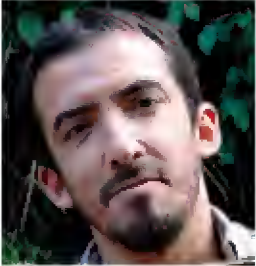
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APPENDIX I

Petracola ventrimaculata.—PERU: CAJAMARCA DEPARTMENT: Celendín province: La Victoria 6° 51' 20.11"S, 78° 18' 25.40"W, 3,449 m, MUSM 26352, 26354–56, 26359; Coñicorgue 6° 50' 0.29"S, 78° 19' 13.40"W, 3,573 m, MUSM 26238–43, 26245, 26353, 26259; Tingo (Sorochocho district) 6° 55' 33.16"S, 78° 18' 59.16"W, 3,410 m, 26357, 27297, 27300, 6° 56' 1.611"S, 78° 20' 34.4862"W, 3,550 m, MUSM 26230; La Chorrera (Sorochocho district) 6° 55' 52.30"S, 78° 18' 55.02"W, 3,267–3,835 m, MUSM 26229, 27295, 27299, 27301; La Encañada 6° 56' 17.02"S, 78° 19' 18.71"W, 3,267 m, MUSM 27298, 27302, 27303; Cerro Las Gordas (Hualgayoc district), MUSM 29879–80; Chugurmayo 6° 53' 35.15"S, 78° 18' 44.17"W, 3,420 m, MUSM 26231–32; Puente Hierba Buena 6° 58' 48.73"S, 78° 22' 44.62"W, 3,360 m, MUSM 26233–35; Jadibamba 6° 50' 17.20"S, 78° 22' 58.54"W, 3,560 m, MUSM 26236; Bajo Quengorio 6° 50' 28.59"S, 78° 25' 52.17"W, 3,410 m, MUSM 26237; Sorochocho y Huasmin 6° 58' 38.98"S, 78° 22' 46.01"W, 3,576 m, MUSM 29504–07, 7° 1' 7.93"S, 78° 18' 46.90"W, 3,466 m, MUSM 29508; NO DATA, MUSM 26260, 26261, 26262; Pampa Grande 7° 1' 42.30"S, 78° 17' 52.69"W, 3,892m, CORBIDI 09239; Michiquillay 7° 1' 41.69"S, 78° 18' 56.09"W, 3,817 m, CORBIDI 9247; Cajamarca province: Laguna Norte 6° 43' 42.8874 S, 78° 42' 57.311" W, 3,593 m; CORBIDI 03630; PIURA DEPARTMENT: Huancabamba province: El Tambo 5° 21' 40.39"S, 79° 33' 9.72"W, 2,981 m, CORBIDI 10482–91, 10498, 10503, 11268–73; 2,700 m, MUSM 15452–56; AMAZONAS DEPARTMENT: Chachapoyas province: Barro Negro 6°42'58.2"S, 77°51'53.8"W, 3,290 m, CORBIDI 11067–75, 11104–26; Leimebamba 6°44'48"S, 77°47'11.6"W, 2,799 m, CORBIDI 11010.



Lourdes Y. Echevarría graduated in biological sciences from Universidad Nacional Agraria La Molina, Lima, Peru, in 2014. As a student, she collaborated constantly in the order and management of the herpetological collections of Centro de Ornitología y Biodiversidad, Lima, developing a great interest in reptiles, especially lizards. For her undergraduate thesis, Lourdes worked on the “Review of the current taxonomic status of *Petracola ventrimaculata* (Cercosaurini: Gymnophthalmidae) using morphological and ecological evidence.” She worked as a researcher of the Museo de Zoología (QCAZ), Pontificia Universidad Católica del Ecuador in Quito during 2015. This manuscript is her first lizard species description. Lourdes is preparing a monograph on the systematics of the *Petracola ventrimaculata* complex based on the results of her undergraduate thesis, as well as other papers about taxonomy of lizards and snakes.



Pablo J. Venegas graduated in Veterinary Medicine from Universidad Nacional Pedro Ruiz Gallo, Lambayeque, Peru, in 2005. He is currently curator of the herpetological collection of Centro de Ornitología y Biodiversidad (CORBIDI). He worked as a researcher of the Museo de Zoología QCAZ, Pontificia Universidad Católica del Ecuador in Quito during 2015. His current research interest is focused on the diversity and conservation of the Neotropical herpetofauna with an emphasis on Peru and Ecuador. He has published more than 40 scientific papers on taxonomy and systematics of Peruvian and Ecuadorian amphibians and reptiles.

In accordance with the International Code of Zoological Nomenclature new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in ZooBank (Polaszek 2005a, b), the official online registration system for the ICZN. The ZooBank publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix “<http://zoobank.org/>.” The LSID for this publication is: urn:lsid:zoobank.org:pub:F1C772A4-E580-4EAA-9BD8-E8A83D276743.

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A new species of montane gymnophthalmid lizard, genus *Cercosaura* (Squamata: Gymnophthalmidae), from the Amazon slope of northern Peru

¹Lourdes Y. Echevarría, ²Andy C. Barboza, and ³Pablo J. Venegas

^{1,2,3}División de Herpetología-Centro de Ornitología y Biodiversidad (CORBIDI), Santa Rita N°105 36 Of. 202, Urb. Huertos de San Antonio, Surco, Lima, PERÚ ^{1,3}Museo de Zoología, Escuela de Ciencias Biológicas, Pontificia Universidad Católica del Ecuador, Avenida 12 de Octubre 1076 y Roca, Apartado 17-01-2184, Quito, ECUADOR

Abstract.—Based on morphological and previously published molecular and phylogenetic evidence, we report the discovery of a new species of *Cercosaura* from the northern portion of Cordillera Central, northern Peru. The new species inhabits the montane forests of northeastern Peru at elevations between 1,788–1,888 m. It differs from other species of *Cercosaura* by having the dorsum lighter than flanks, a white labial stripe that continues along the ventrolateral region until the hind limb insertion, subdigital lamellae on toes not tuberculate, 6–8 longitudinal rows of ventral scales, 32–36 transverse rows of dorsal scales, and dorsal surface of forelimbs and fingers dark brown.

Key words. Central Andes, collar scales, Peruvian Yungas, San Martin, systematics, new species, lizard, South America

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Introduction

The New World lizard clade Gymnophthalmidae Merrem, 1820 comprises 248 extant species belonging to 47 taxa ranked as genera (Colli et al. 2015; Uetz 2015). Gymnophthalmid lizards are small, often secretive and many species have fossorial or semi-fossorial habits (Colli et al. 1998; Pianka and Vitt 2003; Mesquita et al. 2006). They are primarily limited to tropical latitudes, present in the lowland Amazonian forest and foothills, valleys and hill-sides of the Andes (Presch 1980). There are also species that inhabit the Quaternary sand dunes in the São Francisco Basin in Brazil (Rodrigues 1996) to high elevations in the Andes, such as *Proctoporus bolivianus* that can be found at 4,080 m elevation in the Peruvian Andes (Duellman 1979).

The genus *Cercosaura* Wagler, 1830 was reviewed by Doan (2003) using morphological data in a phylogenetic analysis, as a result the genus was redefined to include the genera *Pantodactylus* and *Prionodactylus*, a view that

was corroborated by subsequent molecular studies (Castoe et al. 2004; Doan and Castoe 2005). With the taxonomic changes by Doan (2003), the genus *Cercosaura* contained 11 species distributed throughout the Amazonian, Guianan, and savannah regions of South America, occurring in all its countries, except for Chile, and extending into Panama. Some years later, *Pantodactylus steyeri* was assigned to *Cercosaura* (Bernils et al. 2007), and *C. hypnoides* Doan and Lamar 2012 was described, increasing the number of *Cercosaura* species to 13 (Uetz 2015). Recently, Torres-Carvajal et al. (2015) presented a molecular phylogeny of *Cercosaura* and related taxa, “*Cercosaura*” *vertebralis* and “*Cercosaura*” *dicra* were found to be nested within *Pholidobolus*, and therefore referred to that genus. Furthermore, their phylogenetic hypothesis supported the recognition of *C. argula* and *C. oshaughnessyi* as different species (Avila Pires 1995), and of *C. ocellata bassleri*, as separate species (i.e., *C. bassleri* and *C. ocellata*). Therefore 13 species of *Cercosaura* are currently recognized: *C. argulus* Peters,

Correspondence. Email: ¹lourdese.20@gmail.com (Corresponding author); ²andy_barboza@yahoo.es; ³sancarranca@yahoo.es

1863; *C. bassleri* (Ruibal, 1952); *C. eigenmanni* (Griffin, 1917); *C. hypnoides* Doan and Lamar, 2012; *C. manicata* O'shaughnessy, 1881; *C. nigroventris* (Gorzula and Senaris, 1999); *C. ocellata* Wagler, 1830; *C. oshaughnessyi* (Boulenger, 1885); *C. parkeri* (Ruibal, 1952); *C. phelpsorum* (Lancini, 1968); *C. quadrilineata* (Boettger, 1876); *C. schreibersii* Wiegmann, 1834; and *C. steyeri* (Tedesco, 1998). It should be highlighted that the inclusion of species such as *C. hypnoides*, *C. nigroventris*, *C. parkeri*, *C. phelpsorum*, and *C. steyeri* need to be confirmed by a robust phylogeny that include the mentioned taxa.

Recent fieldwork in the montane forests of San Martín department, northeastern Peru, resulted in the discovery of a potentially new species of *Cercosaura*, which was later confirmed after examination of *Cercosaura manicata manicata* and *C. manicata boliviana* specimens and its position in Torres-Carvajal et al. (2015) phylogeny.

Materials and Methods

Specimens were fixed in 10% formalin for 24 hours, and later stored in 70% ethanol. All type specimens were deposited in the herpetological collection of the Centro de Ornitología y Biodiversidad (CORBIDI), Lima, Peru. Other species of *Cercosaura* examined in this study are deposited at CORBIDI and the Museo de Zoología Pontificia Universidad Católica del Ecuador, Quito (QCAZ), and are listed in Appendix I. Scale counts and color pattern information for *Cercosaura argulus*, *C. eigenmanni*, *C. oshaughnessyi*, and *C. ocellata* were taken from Avila-Pires (1995); *C. quadrilineata*, *C. schreibersii*, and *C. phelpsorum* from Doan (2003); and *C. parkeri* from Soares-Barreto et al. (2012) and *C. steyeri* from Tedesco (1998). Snout-vent length (SVL) and tail length (TL) measurements were taken to 1 mm with a ruler. For characters recorded on both sides, condition on the right side is presented first. Egg volume was calculated using the formula for a prolate spheroid $V = 4/3\pi (\text{length}/2) (\text{width}/2)^2$. Sex was determined by dissection or by noting the presence of hemipenes. We follow the terminology and general description format of Doan and Lamar (2012).

Results

Cercosaura doanae sp. nov.

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Cercosaura sp. Torres-Carvajal et al., 2015: 282 (see discussion).

Figs. 1–3, 4 (upper), 5A, 6C.

Holotype: CORBIDI 00651, adult male from Laguna Negra (06°53'29.3"S, 77°23'18.3"W; WGS 84), 1,788 m, Mariscal Cáceres Province, San Martín Department, Peru, collected by P.J. Venegas and D. Vasquez on 3 February 2008.

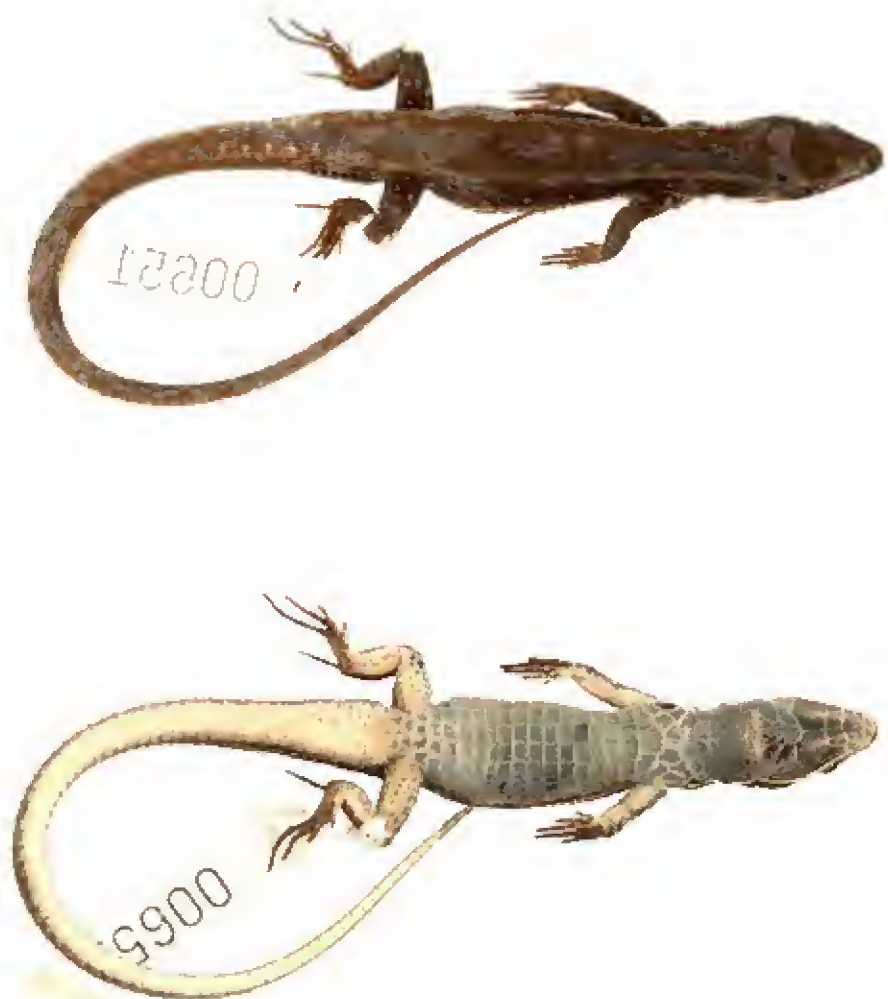


Fig. 1. Holotype (CORBIDI 00651; SVL = 52 mm) of *Cercosaura doanae* sp. nov. in dorsal (upper) and ventral (bottom) views. Photographs by G. Chávez.



Fig. 2. Head of the holotype (CORBIDI 00651) of *Cercosaura doanae* sp. nov. in lateral (A), dorsal (B), and ventral (C) views. Photographs by G. Chávez.



Fig. 3. Holotype of *Cercosaura doanae* sp. nov. in life: dorso-lateral (upper) and ventral (bottom) views. Photographs by P.J. Venegas.

Paratypes (19): PERU: San Martin Department: Mariscal Caceres Province: from type locality CORBIDI 00649, 00656, 00658, 00659 adult females, CORBIDI 00650, 00652, 00660, 00662 juveniles, CORBIDI 00663, 00654, 00655, 00657, 00661 adult males, CORBIDI 00653 subadult female, collected between 2–4 February 2008, by P.J. Venegas and D. Vasquez; Añasco Pueblo (06°50'11.6"S, 77°29'09.7"W), 1,888 m, CORBIDI 00648 a juvenile collected on 2 February 2008 by P.J. Venegas and D. Vasquez; Lajasbamba (06°44'48.4" S, 77°38'25.6" W), 1,814 m altitude, CORBIDI 15074 adult female, CORBIDI 15075 juvenile female, CORBIDI 15076 juvenile male, CORBIDI 15088 adult male collected between 25–28 October 2014 by L.Y. Echevarría and A.C. Barboza.

Diagnosis: *Cercosaura hypnoides* from the Amazon slope of Colombia (Doan and Lamar 2012), *C. manicata manicata* from the Amazon slope of Ecuador and central Peru, and *C. manicata boliviana* Werner, 1899 from southern Peru and Bolivia (Uzzel 1973) are the most similar species to *C. doanae* by having the dorsum lighter than flanks and a light labial stripe. Nevertheless, *Cercosaura doanae* can be distinguished from *C. hypnoides* by having 6–7 supralabials (5 in *C. hypnoides*), dorsal scales in transverse rows (transverse and oblique rows in *C. hypnoides*), and 0–3 lateral scale rows (4–7 in *C. hypnoides*). The new species can be distinguished from *C. manicata boliviana* Werner 1899 (character state of *C. manicata boliviana* in parenthesis) by having a cream labial stripe beginning before the eye, on first or second supralabial,

continuing along the ventrolateral region up to hind limb insertion (light labial stripe beginning under eye and ending before collar fold; Fig. 4, middle), two conspicuous widened collar scales at midline (three or four enlarged collar scales at midline; Fig. 5B), and three posterior cloacal plates in males and five in females (four in males and females). Furthermore, *C. doanae* differs from *C. manicata manicata* (character state of *C. manicata manicata* in parenthesis) by having subdigital lamellae on toes not tuberculate (tuberculate for entire length of toes); and dorsal surface of forelimbs dark brown (brown with a white broad line on brachium, antebrachium, and fingers I, II, III; Fig. 5C).

Furthermore, *Cercosaura doanae* is easily distinguished from *C. argula*, *C. bassleri*, *C. eigenmanni*, *C. ocellata*, *C. oshaughnessyi*, *C. parkeri*, *C. quadrilineata*, and *C. schreibersii* (Fig. 6) in having brown labials with a white stripe extending from the first or second supralabial towards forelimb insertion. *Cercosaura argula* and *C. oshaughnessyi* have labials white or light cream, *C. eigenmanni* has brown labials with white broad vertical bars, *C. bassleri* and *C. ocellata* have creamy gray or gray labials with thin black vertical bars, *C. parkeri* has creamy gray or white labials with dark or faint brown vertical bars, *C. quadrilineata* and *C. schreibersii* have labials varying from creamy gray or dirty cream to white with dark flecks, spots or mottling. Additionally, *C. doanae* can be distinguished from *C. argula* by having an undivided frontonasal (divided in *C. argula*), two genials (three), single lamellae on fingers and toes (mostly divided), 32–36 transverse dorsal scale rows (38–45), 34–42 scales around midbody (27–35), and venter pale orange (white); from *C. eigenmanni* by having 34–42 scales around midbody (26–32 in *C. eigenmanni*), and 9–12 femoral pores in males (6–7); from *C. bassleri* and *C. ocellata* by having hexagonal dorsal scales (quadrangular in *C. bassleri* and *C. ocellata*), scales on flanks slightly smaller than dorsals,



Fig. 4. Lateral views of male specimens of (upper) *Cercosaura doanae* (holotype), (middle) *C. manicata boliviana* (CORBIDI 16500), and (bottom) *C. manicata manicata* (CORBIDI 08797). Photographs by J.C. Chávez-Arribasplata.

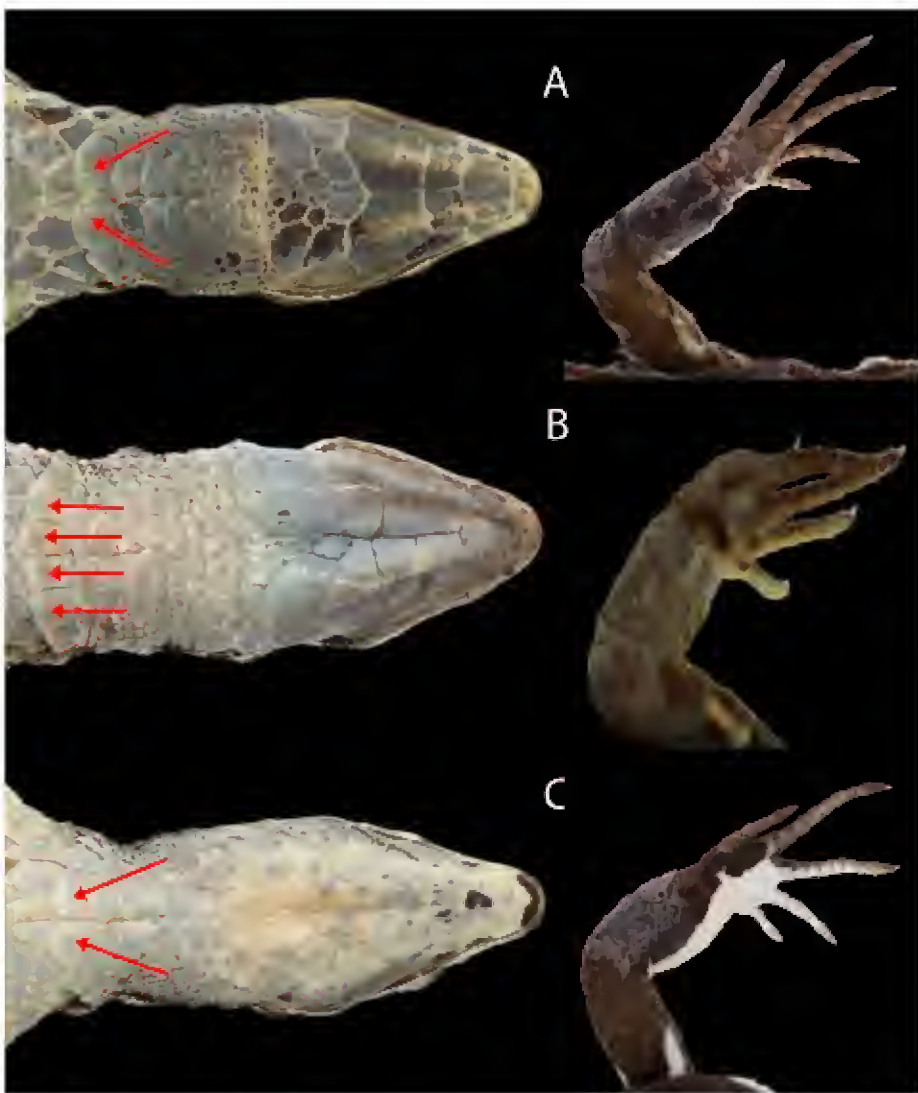


Fig. 5. Ventral views of heads and dorsal surface of the forelimbs of (A) *Cercosaura doanae* sp. nov. (holotype), (B) *C. manicata boliviiana* (CORBIDI 14272), and (C) *C. manicata manicata* (CORBIDI 08797); showing the collar scales and the striking white line along the brachium, antebrachium, and fingers I, II, III of *C. manicata manicata*. Red arrows indicate the collar scales at midline. Photographs by D. Quirola and J.C. Chávez-Arribasplata.

keeled (scales on flanks distinctly smaller than dorsals, smooth or slightly keeled), lamellae on toes single (mostly divided), 10–13 lamellae under fourth finger (14–18), and 15–18 lamellae under fourth toe (16–24); from *C. oshaughnessyi* by having a single frontonasal (divided in *C. oshaughnessyi*), 32–36 transverse dorsal scale rows (37–52), scales on flanks slightly smaller than dorsals (scales on flanks distinctly smaller and sharply delimited from dorsals and ventrals), and venter orange (white); from *C. parkeri* by having 34–42 scales around midbody (24–30 in *C. parkeri*), 9–12 femoral pores in males (2–6), and lateral scales slightly smaller than dorsals (lateral scales similar in size to dorsals); from *C. quadrilineata* by having 6–8 longitudinal rows of ventral scales (four in *C. quadrilineata*), 16–19 transverse rows of ventral scales (21–23), and 9–12 femoral pores in males (eight); from *C. schreibersii* by having 16–19 transverse ventral scale rows (17–24 in *C. schreibersii*), and 9–12 femoral pores in males (3–5).

Cercosaura doanae can be distinguished from both *C. nigroventris* and *C. phelpsorum* by having subdigital lamellae on toes not tuberculate (tuberculate in *C. nigroventris* and *C. phelpsorum*) and by ventral coloration in preservative, having creamy tail (beige and dark brown in *C. nigroventris* and *C. phelpsorum*, respectively) (Doan 2003).

The new species differs from the poorly known *Cercosaura steyeri* in having 6–8 longitudinal rows of ventral scales (four in *C. steyeri*), dorsal scales not mucronate (strongly mucronate), 34–42 scales around midbody (17), and 15–18 lamellae on Toe IV (14).

Pholidobolus hillisi and the former *Cercosaura* species, *P. dicra* and *P. vertebralis* (see Torres-Carvajal et al. 2015), are also very similar to *C. doanae* in having dorsum lighter than flanks, brown labials with a white or light cream labial stripe that extends towards the forelimb insertion, and hexagonal and strongly keeled dorsal scales. However, the new species can be readily distinguished from all these *Pholidobolus* species by lacking a light vertebral stripe, which in *P. dicra* bifurcates anteriorly at midbody, and by having the loreal scale in contact with supralabials (in the aforementioned species of *Pholidobolus* the loreal scale is not in contact with supralabials). Additionally, it can be distinguished from *P. hillisi* (in parenthesis) by lacking a distinct diagonal white stripe on each side of the chin, extending from the fourth genial to the forelimb (present); from *P. dicra* (in parenthesis) by having three supraoculars (four); and from *P. vertebralis* (in parenthesis) by having palpebral disc single or divided, usually into 2–3 scales (divided, into 5–8 scales).

Characterization: (1) supraoculars three; (2) superciliaries 3–4, first expanded onto dorsal surface of head; (3) palpebral eye-disc made up of a single or divided transparent scale; (4) supralabials 6–7; (5) infralabials 5–7; (6) dorsal body scales hexagonal, strongly keeled; (7) dorsal scales only in transverse rows; (8) transverse rows of dorsals 32–36; (9) a continuous series of small lateral scales (usually two) separating dorsals from ventrals; (10) two conspicuous widened collar scales at midline; (11) transverse rows of ventrals 16–19; (12) longitudinal rows of ventrals 6–8; (13) femoral pores per hind limb 9–12 in males, 0–9 in females; (14) precloacal pores absent; (15) posterior cloacal plates three in males, five in females; (16) subdigital lamellae on toe IV 15–18; (17) limbs overlapping when adpressed against body; (18) dorsum brown; light brown dorsolateral stripe present, extending from loreal onto the tail; flanks chocolate brown, darker than dorsum; cream labial stripe, starting on second or third supralabial and running continuously as a ventrolateral creamy brown stripe along the body; black ocelli with white or creamy brown center present along the flanks; (19) ventrally throat and neck pinkish gray; chest yellowish orange; venter yellowish orange in males and pinkish brown in females, ventral surface of hind limbs and ventral surface of tail orange, becoming grayish cream towards the tip; and ventral surface of forelimbs yellow.

Description of holotype: Adult male (CORBIDI 00651), hemipenes not everted, SVL = 52 mm, tail complete, TL = 108 mm; head scales rugose and porous; rostral scale wider than tall, meeting supralabials on either



Fig. 6. Some species of *Cercosaura*: (A) *C. argula* (CORBIDI 12634) from Ere river, Loreto, Peru; (B) *C. bassleri* (CORBIDI 13208) from Bahuaja Sonene National Park, Puno, Peru; (C) *C. doanae* **sp. nov.** (CORBIDI 661) from Laguna Negra, San Martin, Peru; (D) *C. eigenmanni* from Porto Velho, Rondônia, Brazil; (E) *C. manicata manicata* (CORBIDI 9217) from Cordillera Azul National Park, San Martin, Peru; (F) *C. manicata boliviiana* (CORBIDI 16500) from San Pedro, Cusco, Peru; (G) *C. ocellata* from Para, Brazil; (H) *C. oshaughnessyi* (CORBIDI 12637) from Ere river, Loreto, Peru; and (I) *C. schreibersii* from Iperó, São Paulo, Brazil. Photographs by: A–C, E, and H by P.J. Venegas; F by A. Catenazzi; G by P. Melo-Sampaio; D and I by M. Teixeira-Junior.

side at above the height of supralabials, in contact with frontonasal, nasals, and first supralabials; frontonasal wider than long, hexagonal, in contact with nasals and prefrontals, shorter than frontal; prefrontals present, not in contact; frontal longer than wide, hexagonal, in contact with anteriormost supraocular, prefrontals, and frontoparietals; frontoparietals pentagonal, in contact with all three supraoculars, parietals and interparietal; supraoculars three, first supraocular in contact with first three superciliaries, second supraocular in contact with third superciliary, third supraocular in contact with fourth superciliary, one postocular, and parietal; interparietal longer than wide, heptagonal, in contact with parietals and occipitals; parietals hexagonal, in contact with one postocular, a subequally large supratemporal, and one occipital; occipitals three, smaller than parietals, median one smallest, extending further posteriorly than two lateral occipitals. Nasal longer than high, nostril situated anteriorly, in contact with first and second supralabials and lo-

real; loreal irregularly pentagonal, in contact with second supralabial, frenocular, and first superciliary; frenocular subtriangular, dorsal most corner in contact with first superciliary, in contact with second and third supralabials, preocular, and first subocular; four superciliaries, first expanded onto dorsal surface of head; two preoculars (right) and one (left), in contact with first superciliary in both sides; palpebral eye-disc made up of a single (right) and divided into two transparent scales (left); suboculars five; postoculars two; temporal rugose polygonal; supratemporals two, first largest; ear opening oblong, tympanum recessed; supralabials seven; infralabials six. Mental wider than long, in contact with first infralabial and postmental posteriorly; postmental single, pentagonal, posterior suture angular with point directed posteriorly, in contact with first and second infralabials and first pair of genials; two pairs of genials, anterior pair in contact with second and third infralabials, second genials in contact with third and fourth infralabials; two pairs of chin shields, sepa-

rated by irregular preulars; four rows of preular scales; gular scale rows three; collar fold distinct; lateral neck scales granular.

Dorsals hexagonal, longer than wide, with posterior margins slightly curved, imbricate, with a single high, rounded keel, in 34 transverse rows, oblique rows absent; longitudinal dorsal scale rows 25 at fifth transverse ventral scale row, 27 at tenth transverse ventral scale row, 17 at fifteenth transverse ventral scale row; small, slightly keeled lateral scale series, two scales wide, approximately half the size of dorsals, ovoid, smaller and more numerous rounded lateral scales at limb insertion regions; lateral fold present. Ventral scales smooth, squarish with rounded posterior margins, imbricate, in 17 transverse rows; longitudinal ventral scale rows at midbody six; anterior precloacal plate paired, three scales on posterior precloacal plate. Scales on tail like those on body; dorsal and dorsolateral caudal scales hexagonal and keeled, ventral and ventrolateral caudal scales square, smooth.

Limbs pentadactyl; digits clawed; dorsal brachial scales polygonal, subequal in size, imbricate, keeled; ventral brachial scales much smaller than dorsal scales, round, juxtaposed, smooth; dorsal antebrachial scales polygonal, subequal in size, multicarinate; ventral antebrachial scales polygonal, subequal in size, smooth. Scales on dorsal surface of manus polygonal, smooth, subimbricate; scales on palmar surface of manus small, rounded, subimbricate, domelike; thenar scales two, smooth; finger length formula $IV > III > II > V > I$; scales on dorsal surfaces of fingers smooth, quadrangular, covering dorsal half of digit, overhanging supradigital lamellae 4 on I, 6 on II, 8 on III, 9 on IV, 5 on V; subdigital lamellae 6 on I, 10/9 on II, 13/13 on III, 14/14 on IV, and 9/9 on V. Scales on anterodorsal surface of thigh large, polygonal, keeled, imbricate; scales on posterior surface of thigh small, rounded, subimbricate; scales on ventral surface of thigh large, rounded, flat, smooth; femoral pores nine (right) and 10 (left); precloacal pores absent; scales on anterior surface of crus polygonal, keeled, subimbricate, decreasing in size distally; scales on anterodorsal surface of crus polygonal, subimbricate, keeled; scales on ventral surface of crus large, polygonal, smooth, flat, and imbricate. Scales on dorsal surface of pes polygonal, keeled, subimbricate; scales on palmar surface of pes small, rounded, subimbricate, domelike; toe length formula $IV > III > V > II > I$; scales on dorsal surface of digits single, quadrangular, smooth, of varying sizes, overhanging supradigital lamellae 3 on I, 6 on II, 9 on III, 10 on IV, and 7 on V; subdigital lamellae single and tuberculate along the toes, 6/6 on I, 10/11 on II, 15/16 on III, 18/18 on IV, and 15 on V; limbs overlapping when adpressed against the body.

Coloration of holotype in life: Dorsal and lateral surfaces of head brown; a distinct cream stripe initiates on the ventral most portion of second supralabial scale and continues through all supralabials onto body, after second supralabial the stripe bends dorsally across third supra-

labial and to the top of supralabials 4, 5, 6, and 7, then the stripe bends ventrally in a straight line to the bottom of the auricular opening, onto the body as a ventrolateral stripe. Dorsal surface of body brown. Faint light brown dorsolateral stripes from first superciliary onto tail. Lateral surface of body chocolate brown; lateral stripe from head continues over forelimb insertion, ending at hind limb insertion. Nine black ocelli with cream center, from neck to hind limb insertion, and six ocelli on the base of tail. Dorsal surface of forelimbs same color of dorsum, with a faint ocellus of creamy brown center on dorsal surface of ante brachium; dorsal surfaces of manus brown with cream pigmentation on some scales. Dorsal surfaces of hind limbs brown with an ocellus near hind limb insertion and few creamy brown spots; dorsal surfaces of pes brown with coppery brown pigmentation on some scales. Dorsal tail coloration brown with scattered light brown and black marks. Lateral surfaces of tail brown.

Ventral surface of head and neck pinkish gray. Venter yellowish orange. Ventral surface of forelimbs yellow, ventral surface of hind limbs pale orange with dark gray flecks. Ventral surface of tail orange becoming cream towards the end. Iris brown.

Coloration of holotype in preservative (ethanol 70%): Dorsum darker brown; faint light brown dorsolateral stripes light gray and barely distinct from dorsum coloration; flanks lighter brown. Ventrally head, neck, chest, and venter are dark gray and ventral surface of limbs and tail dirty cream.

Variation: Measurements and scale counts of *Cercosaura doanae* are presented in Table 1. Supraoculars usually three; one specimen (CORBIDI 00659) has two supraoculars on left side and three on right side. Usually four superciliaries; only specimen CORBIDI 00662 presents three superciliaries on each side. Seven supralabials in most specimens; 6/6 in specimens CORBIDI 00662, 00648, and 15088 (15%), and 7/6 in specimens CORBIDI 15075, 15076 (10%). Usually six infralabials; 5/4 in CORBIDI 15075, 5/5 in CORBIDI 00652, 00654, 15074, and 15076 (20%), 5/6 in CORBIDI 00656, 15088 (10%), 6/5 in CORBIDI 00648, 00662 (10%), and 6/7 in CORBIDI 00658. Specimen CORBIDI 00659 (5%) has 3/2 postocular scales. Usually 3/3 supratympanic temporals (50%); specimens CORBIDI 00649, 00652, 00655, 00658, 00661 have 4/4 (25%), specimens CORBIDI 15074, 16076, 15088 have 4/3 (15%), and CORBIDI 00653 has 3/4. Specimen CORBIDI 15075 has only one pair of genials. Sexual dimorphism present in number of cloacal plates; male specimens have two anterior and three posterior cloacal plates (88%), only CORBIDI 00654 has four anterior plates. Female specimens have usually two anterior and five posterior cloacal plates (67%); CORBIDI 00659 has four anterior plates and CORBIDI 00649 has four posterior plates. Palpebral disc transparent, undivided in specimens CORBIDI 00648,

A new species of montane gymnophthalmid lizard, genus *Cercosaura*

Table 1. Variation in scutellation, sexual dimorphism in SVL (mm), and color pattern of *Cercosaura doanae* sp. nov., *C. manicata manicata*, and *C. manicata boliviana*. Range followed by mean \pm standard deviation is given for quantitative characters if applicable.

Character	<i>Cercosaura doanae</i> (n = 20)	<i>Cercosaura manicata</i> <i>manicata</i> (n = 15)	<i>Cercosaura manicata</i> <i>boliviana</i> (n = 3)
Supraoculars	3	3	3
Superciliaries	3–4 3.95 \pm 0.22	3–4 3.87 \pm 0.35	4
Genials	1–2 1.95 \pm 0.22	2	2–3 2.67 \pm 0.58
Supralabials	6–7 6.85 \pm 0.37	5–7 5.53 \pm 0.83	5–7 6.33 \pm 1.15
Infralabials	4–7 5.65 \pm 0.67	4–5 4.4 \pm 0.51	5
Transverse dorsal scale rows	32–36 33.1 \pm 1.07	34–41 37.33 \pm 2.41	35–40 ¹
Longitudinal dorsal scale rows	22–30 24.8 \pm 1.88	29–35 32.67 \pm 1.91	26–27 26.33 \pm 0.58
Transverse ventral scale rows	16–19 17.4 \pm 0.82	17–21 19.13 \pm 1.06	19(18) ¹ –23 21 \pm 1.15
Longitudinal ventral scale rows	6–8 7.9 \pm 0.45	6 ¹ –8	8
Scales around midbody (at 10 th transverse ventral scale row)	34–42 37.45 \pm 1.93	41–50 45.4 \pm 2.29	33–41 ¹
Lateral scale rows	0–3	0–4	
Femoral pores per hind limb in males	9–12 10.5 \pm 1.19	10–14 11.83 \pm 1.33	7
Femoral pores per hind limb in females	0–9 6 \pm 3.11	8–13 10.33 \pm 2.52	3
Posterior cloacal plates in males	3	2–3	4
Posterior cloacal plates in females	4–5 4.86 \pm 0.38	4–5	4
Lamellae on 4 th toe	15–18 16.7 \pm 0.86	15–17 15.73 \pm 0.8	19–23
Lamellae on 4 th finger	10–13 11.55 \pm 0.76	10–13 11.33 \pm 0.82	13–15 14 \pm 1
Maximum SVL in males (mm)	52.06	61.62	56 ¹
Maximum SVL in females (mm)	55.59	59.35	58 ¹
Collar scales at midline	Two conspicuous and widened	Two conspicuous and widened	Three or four, enlarged
Beginning and extent of labial stripe	Before the eye, on first or second supralabial, continuing along the ventrolateral region up to hind limb insertion	First supralabial, continuing along the ventrolateral region up to hind limb insertion	Under eye and ending before collar fold
Color on dorsal surface of forelimbs	Dark brown	Brown with a white broad line on brachium, antebrachium and fingers I, II, III	Brown

¹Data from Uzzel (1973).

00652, 00653, 00660, 00662, 15074–76, 15088 (45%), and divided in two or three sections in CORBIDI 00649, 00650, 00654–59, 00661, 00663 (55%).

Dorsal coloration is identical in all specimens, including juveniles. Faint ocelli, with white or creamy brown center, on dorsal surface of antebrachium and few or several creamy brown spots are present in adults and juveniles. Ventral coloration of head and venter in males vary from grayish pink and pale orange, respectively, like in the holotype, to complete white throat and venter (CORBIDI 15088). Adult females differ from adult males by having the ventral surface of head, throat, and venter pinkish brown, and the ventral surface of tail yellow. Lateral ocelli present in male specimens CORBIDI 00651, 00654, 0657, 00661, 15088 (25%), and female CORBIDI 00659 (5%). Ocelli on hind limb present in two specimens (CORBIDI 15088 and holotype).

Distribution and natural history: *Cercosaura doanae* is known only from three localities in the head waters of the Huayabamba basin, San Martín department, at elevations of 1,788–1,888 m, along the Amazon slope of the extreme northern portion of Central Andes in northern Peru (Fig. 7). It inhabits the Amazonian premontane forest in the Yungas ecoregion (500–2,300 m) according to Brack (1986) and Peñaherrera del Aguila (1989), and Peruvian Yungas ecoregion according to Olson et al. (2001). The new species was found active on sunny days in pasturelands for cattle surrounded by forest in Añasco Pueblo and Lajasbamba (Fig. 8A). All observed individuals were moving through the herbaceous vegetation, and hiding in it when disturbed. At Laguna Negra, the new species was very abundant, moving at day through the leaf litter in primary forest (Fig. 8B). When disturbed, individuals run and hid within leaf litter, fallen trees, and in roots at the base of trees. Female specimen CORBIDI 00659, collected on 4 February 2008, contained two oviductal eggs, right egg was 12.1 mm × 6.6 mm and left egg 12.3 mm × 6.7 mm, and their respective volumes as 279.86 mm³ and 291.38 mm³.

Etymology: The specific epithet is a noun in the genitive case and patronym for Tiffany Doan, in recognition of her contribution to the systematics of gymnophthalmid lizards (e.g., Doan 2003; Doan and Castoe 2005), and to the knowledge of the herpetofauna from southern Peru.

Discussion

The Neotropical genus *Cercosaura* is a poorly sampled taxa that surely has several undescribed species. In a recent molecular phylogeny of *Cercosaura* and related taxa, Torres-Carvajal et al. (2015) showed distinction between *C. doanae* **sp. nov.** (cited as *Cercosaura* sp.) and *C. manicata manicata* (cited as *C. manicata*) as sister species with strong support (PP = 1.00), and separated

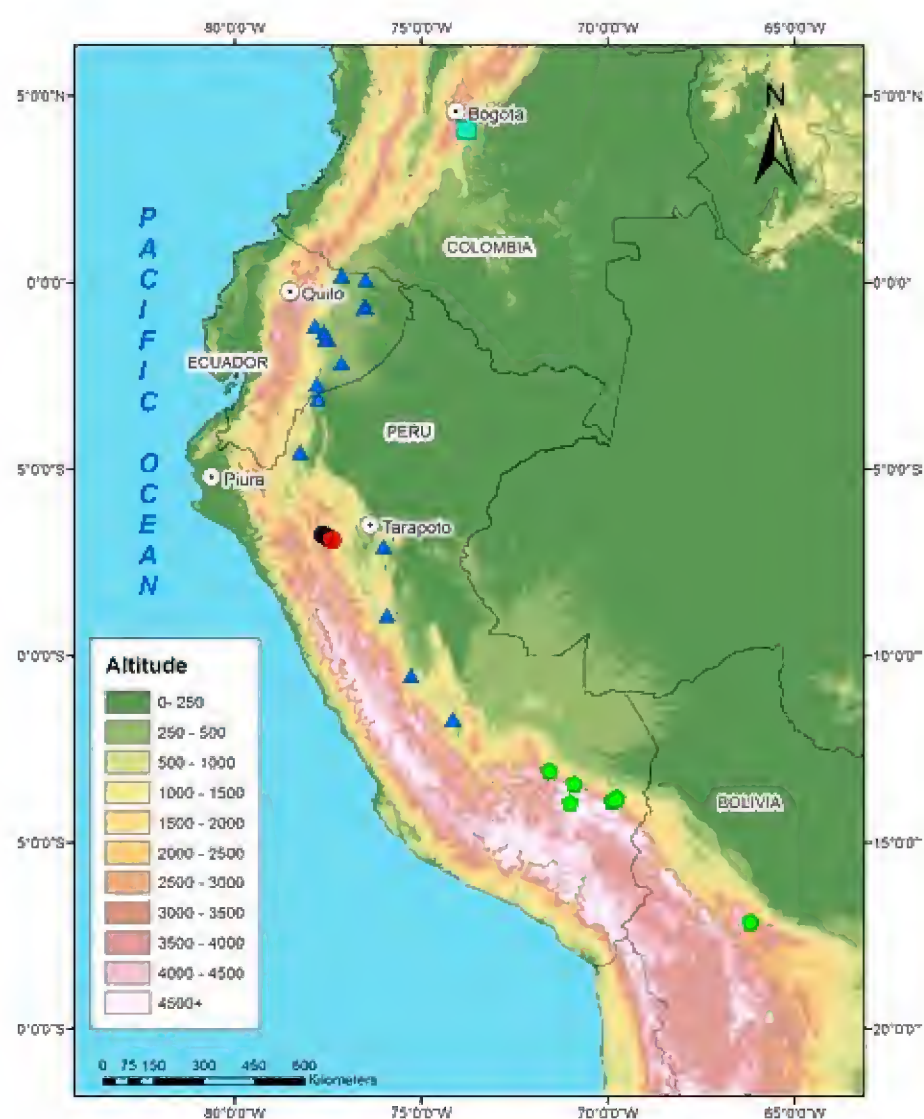


Fig. 7. Distribution of *Cercosaura doanae* **sp. nov.** (circles), *C. manicata boliviiana* (green pentagons), *C. manicata manicata* (blue triangles), and *C. hypnoides* (sky blue square). Red circle indicates the type locality of the new species. Locality data from the literature (Doan and Lamar 2012; Uzzel 1973) and specimens deposited at Centro de Ornitología y Biodiversidad (CORBIDI) and Museo de Zoología of Pontificia Universidad Católica del Ecuador.

by branches that are similar in length to other branches separating sister species among *Cercosaura*. Additionally, the position of both species within the *Cercosaura* clade is strongly supported (PP = 1.00) as a basal subclade. However, the genetic distance values between the new species and *C. manicata manicata* are lower (12S = 0.015, 16S = 0.016, ND4 = 0.032, and c-mos = 0.004) than the interspecific ranges reported by the authors. For example, the genetic distance values between two largely recognized species as *C. eigenmanni* and *C. ocellata* are 0.031 for 12S, 0.019 for 16S, 0.060 for ND4, and 0.007 c-mos. We are confident in the separation of *C. doanae* **sp. nov.** and *C. manicata manicata*, since the morphological differences between both species are clear (i.e., the absence versus presence of tuberculate lamellae and the coloration of forearms; see diagnosis above and Figure 5C), and support the phylogenetic distinction. Although, samples of *C. manicata boliviiana* are not included in the phylogenetic tree of Torres-Carvajal et al. (2015), clear differences can be recognized between the new species and *C. manicata boliviiana* (e.g., beginning of labial stripe, size, and number of collar scales at midline and the number of posterior cloacal plates; see diagnosis above and Figures 4–5).

Uzzel (1974) gave clear differences between *C. manicata boliviiana* and *C. manicata manicata*, all of them confirmed in the specimens examined by us. Both subspecies can be easily distinguished from each other morphologically (see Figures 4–6) and occur in allopatry (see Figure 7). In fact, we consider that there is enough morphological evidence to consider *C. manicata boliviiana* as a distinct taxa, but it needs to be confirmed with robust molecular data. We believe that *Cercosaura doanae* **sp. nov.** and both subspecies of *C. manicata* represent a species complex.

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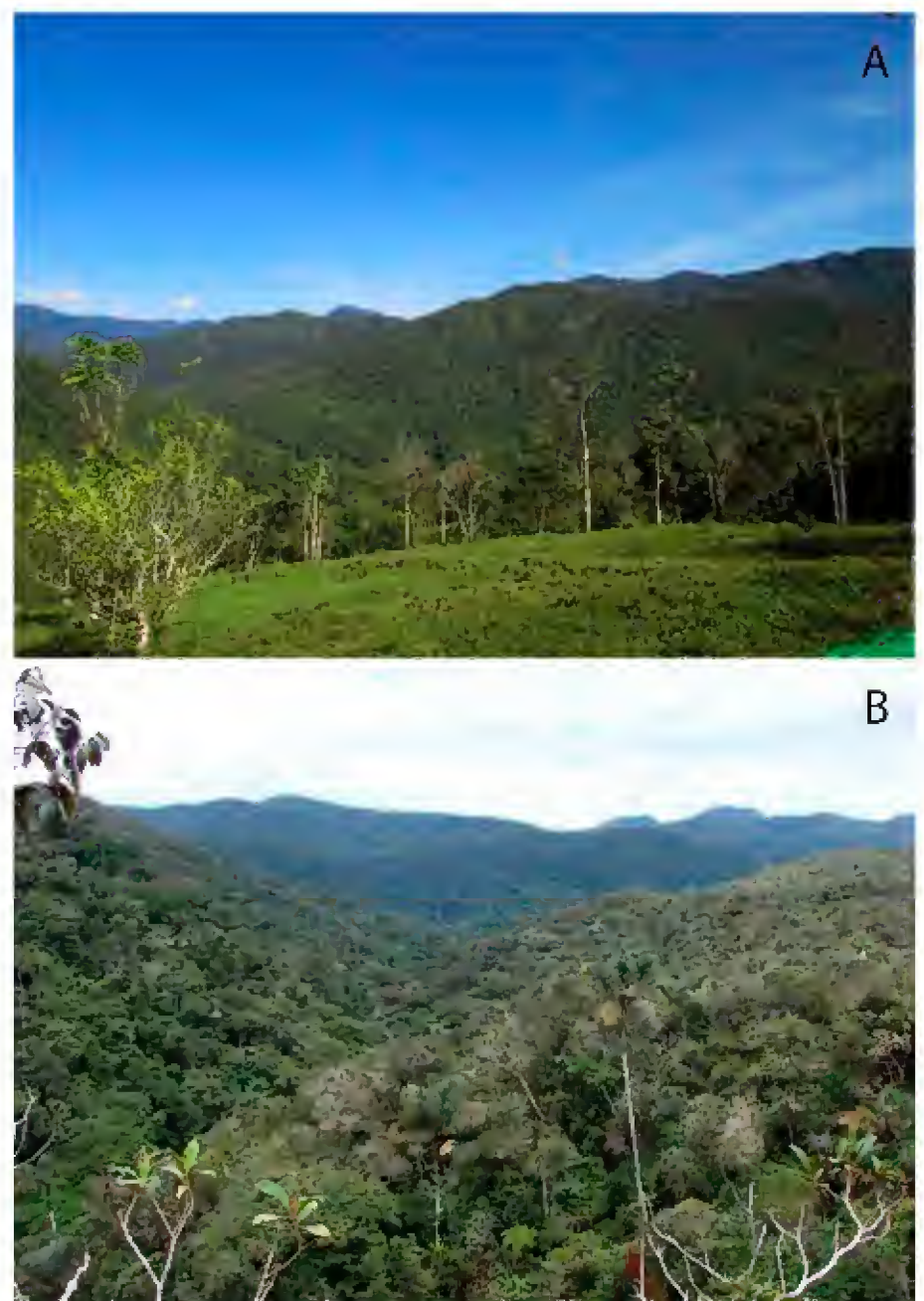


Fig. 8. Habitat of *Cercosaura doanae* **sp. nov.**: (A) landscape of Lajasbamba showing the pasturelands for cattle and montane forest (photograph taken on October 2014 by L.Y. Echevarría); (B) landscape of the primary forest at the type locality. Photograph taken on February 2008 by P.J. Venegas.

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Appendix I

Specimens examined

Cercosaura manicata manicata.—ECUADOR: Provincia Pastaza: Campo Oglán (AgipOil), QCAZ 5793, 5821; Pablo López de Oglán Alto, QCAZ 11818; Campamento K10, Campo Villano (AgipOil), 1°28'32.12"S, 77°32'5.53" W, QCAZ 11831. PERU: Departamento Loreto: Provincia Datem del Marañon: Pongo Chinim, 3° 6' 46.8"S, 77° 46' 34.4" W, 365 m, CORBIDI 09406. Departamento San Martin: Provincia Picota: Puesto de Control 16 Chambirillo (PN Cordillera Azul), 7°4'8.9"S, 76°0'55.2"W, 1,122 m, CORBIDI 08796, 08797, 08836, 08837, 09217, 10419, 10421, 10422; rio Chambira, CORBIDI 03659; Shamboyacu, CORBIDI 06774.

Cercosaura manicata boliviana.—PERU: Departamento de Cusco: Capire 13° 25' 22.27 "S, 70°54'12.16" W, 1,237 m, CORBIDI 14272; Pitumarca, 13° 55' 5.64 "S, 71°0'43.81" W, 4,889 m, CORBIDI 14704; San Pedro, 13° 3' 51.012 "S, 71°33'37.44" W, 1,560 m, CORBIDI 16500.

Pholidobolus dicra.—ECUADOR: Provincia Morona Santiago: Guarumales, 2° 34' 0.0006" S, 78° 30' 0" W, 1,700 m, QCAZ 5292, 5304. Provincia Tungurahua: Río Blanco, Vía Baños-Puyo, 1° 23' 55.6434" S, 78° 20' 24" W, 1,600 m, QCAZ 6936, no locality data QCAZ 8015.

Pholidobolus hillisi.—ECUADOR: Provincia Zamora-Chinchipe: near San Francisco Research Station on Loja-Zamora road, 3°57'57"S, 79°4'45"W, WGS84, 1,840 m, QCAZ 4998-99, 5000; San Francisco Research Station, 3°58'14"S, 79°4'41"W, 1,840 m, QCAZ 6840, 6842, 6844.

Pholidobolus vertebralis.—ECUADOR: Provincia Carchi: Chilma Bajo, 0°51'53.83"N, 78°2'59.26" W, 2,071 m, QCAZ 5057, 8671-8673, 8678, 8679, 8717, 8724, 0°51'50.31"N, 78°2'50.05" W, 2022, QCAZ 8684-8689. Provincia Pichincha: Mindo, 0°3'2.41"S, 78°46'18.77" W, 1,700 m, QCAZ 2911, 2912, 2915, 0°4'40.98"S, 78°43'55.02" W, 1,601 m, QCAZ 7528; Cooperativa El Porvenir, El Cedral 0°6'50.40"N, 78°34'11.75" W, 2297 m, QCAZ 5081, 5082; Santa Lucia de Nanegal, 0°6'48.70"N, 78°36'48.60" W, 1,742 m, QCAZ 10667, 0°7'8.51"N, 78°35'58.70" W, 1900 m, QCAZ 10750.

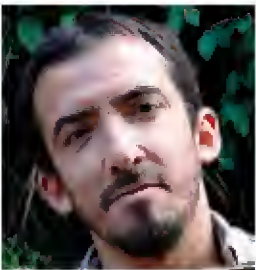
A new species of montane gymnophthalmid lizard, genus *Cercosaura*



Lourdes Y. Echevarría graduated in Biological Sciences from Universidad Nacional Agraria La Molina, Lima, Peru, in 2014. As a student, she collaborated constantly in the order and management of the herpetological collection of Centro de Ornitología y Biodiversidad (CORBIDI) developing a great interest in reptiles, especially lizards. For her undergraduate thesis, Lourdes worked on the “Review of the current taxonomic status of *Petracola ventrimaculatus* (Cercosaurini: Gymnophthalmidae) using morphological and ecological evidence.” She has continued to work as a researcher at the Museo de Zoología (QCAZ), Pontificia Universidad Católica del Ecuador in Quito in 2015. Lourdes is preparing a monograph on the systematics of the *Petracola ventrimaculatus* complex based on the results of her undergraduate thesis, as well as other papers about the taxonomy of lizards and snakes.



Andy C. Barboza graduated in Biological Sciences from Universidad Nacional de Trujillo, La Libertad, Peru in 2012. She works as collection manager of the amphibian collection of Centro de Ornitología y Biodiversidad (CORBIDI). For her undergraduate thesis she worked on the “Composition and altitudinal distribution of amphibians from Otishi National Park,” in collaboration with Missouri Botanical Garden (GMB). Her current research interest is focused on the systematics, diversity, and conservation of Neotropical herpetofauna, particularly from Peru, and the evolutionary history and behavior of amphibians facing climate change.



Pablo J. Venegas graduated in Veterinary Medicine from Universidad Nacional Pedro Ruiz Gallo, Lambayeque, Peru, in 2005. He is currently curator of the herpetological collection of Centro de Ornitología y Biodiversidad (CORBIDI) and worked as a researcher at the Museo de Zoología QCAZ, Pontificia Universidad Católica del Ecuador in Quito in 2015. His current research interest is focused on the diversity and conservation of the Neotropical herpetofauna with emphasis in Peru and Ecuador. So far he has published more than 40 scientific papers on taxonomy and systematics of Peruvian and Ecuadorian amphibians and reptiles.



A new species of *Anolis* (Squamata: Iguanidae) from Panama

^{1,3}Steven Poe, ²Simon Scarpetta, and ¹Eric W. Schaad

¹Department Of Biology, Castetter Hall, University of New Mexico, Albuquerque, New Mexico 87131, USA ²Field Conservation Facility, 477 Oak Road, Stanford University, Stanford, California 94305, USA

Abstract.—We describe *Anolis elcopeensis*, a new species of anole lizard from low to moderate elevations of the Pacific slope of the Cordillera Central of central Panama. *Anolis elcopeensis* is a close relative of and resembles the Amazonian species *A. fuscoauratus* but differs from it and similar species mainly in body size, male dewlap color, and mitochondrial DNA. We estimate the phylogenetic position of the new species relative to all species of *Anolis*, and analyze variation in the mitochondrial COI gene among some populations of the new species. We also discuss the mythical presence of *Anolis fuscoauratus* in Panama, document the possible occurrence of *A. maculiventris* in Panama, and present preliminary evidence for multiple cryptic *fuscoauratus*-like species in eastern Panama.

Key words. Central America, cryptic species, Darién, lizard, Panama, Reptilia

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Introduction

Panama continues to yield new species of lizards and frogs annually despite already displaying one of the highest herpetofaunal diversities in Central America (Kohler 2008, 2011). Thirteen new species of *Anolis* have been described from Panama since 2007 to bring the number of *Anolis* species known from Panama to 44. The dynamic biogeographic history of Panama as a land bridge between North and South America has been cited as an explanation for the extraordinary faunal diversity of this country (Savage 1983).

Herpetologists working in Panama have long known of an undescribed species of *Anolis* similar to *A. fuscoauratus* from Barro Colorado Island (BCI) and other areas (Myers and Rand 1969; Ibañez et al. 1994; Stan Rand, pers. comm. 2003). This abundant species has remained undescribed probably due to its lack of distinctive characteristics and resemblance to other nondescript anoles in Central and South America. *Anolis* species similar to *A. fuscoauratus* frequently are straightforwardly differentiable only by male dewlap color. We have collected numerous examples of this undescribed species from its known localities and several new localities and have con-

firmed its uniqueness using molecular and morphological data. We describe this form from material collected west of the Panama Canal Zone and provisionally assign the well-known Canal Zone populations to this species. We also present evidence that this form is part of a complex of central and eastern Panamanian species similar to *Anolis fuscoauratus*.

Materials and Methods

We adopt the evolutionary species concept (Simpson 1961; Wiley 1978) and operationalize this concept by identifying species based on consistent differences between populations. That is, we hypothesize that populations or sets of populations that are diagnosable by major differences in the frequencies of traits are distinct evolutionary lineages or species.

Measurements were made with digital calipers on preserved specimens and are given in millimeters (mm), usually to the nearest 0.1 mm. Snout-vent length (SVL) was measured from tip of snout to anterior margin of cloaca. Head length was measured from tip of snout to anterior margin of ear opening. Femoral length was measured

Correspondence. Email: ³anolis@unm.edu (Corresponding author)

from midline of venter to knee, with limb bent at a 90° angle. Head width was measured at the broadest part of the head, between the posterolateral corners of the orbits. Scale terminology and characters used mainly follow standards established by Ernest Williams for species descriptions of anoline lizards (e.g., Williams et al. 1995). Museum abbreviations follow Sabaj Perez (2014). Type specimens were deposited in the Museum of Southwestern Biology (MSB) of the University of New Mexico.

Phylogenetic analyses

We first identified a hypothesized undescribed species of *Anolis* based on a discovered population’s all-orange male dewlap, small body size, and morphological and genetic distinctness (see below). In order to determine the phylogenetic position of the new species and identify appropriate species for comparison, we included the putative new species in phylogenetic analyses of all rec-

ognized species in the genus *Anolis* as of 01 June 2014 (results not shown). We collected morphological and mitochondrial COI data for the putative species and combined these with existing data for multiple genes (Alfoldi et al. 2012; the informal name “sunni” in supplementary appendices refers to this form but is not listed in the published paper) and additional new collected data. Preliminary phylogenetic analyses of this hypothesized species and all known species of *Anolis* suggested this form to be a member of a strongly supported clade of 14 Central and South American species similar to *A. fuscoauratus* (we henceforth refer to these species as the “*fuscoauratus* group”). We analyzed this sample of 15 species with two outgroups (*A. carpenteri*, *A. polylepis*) using a partitioned Bayesian Analysis (Ronquist et al. 2012) with one “mixed” GTR model with rate heterogeneity for the DNA sequence data (24879 sites) and another “standard” model for morphological data (46 characters). We ran the analysis for 2,000,000 generations, sampling every 1,000 trees, and discarded the first 50% of samples as burnin.

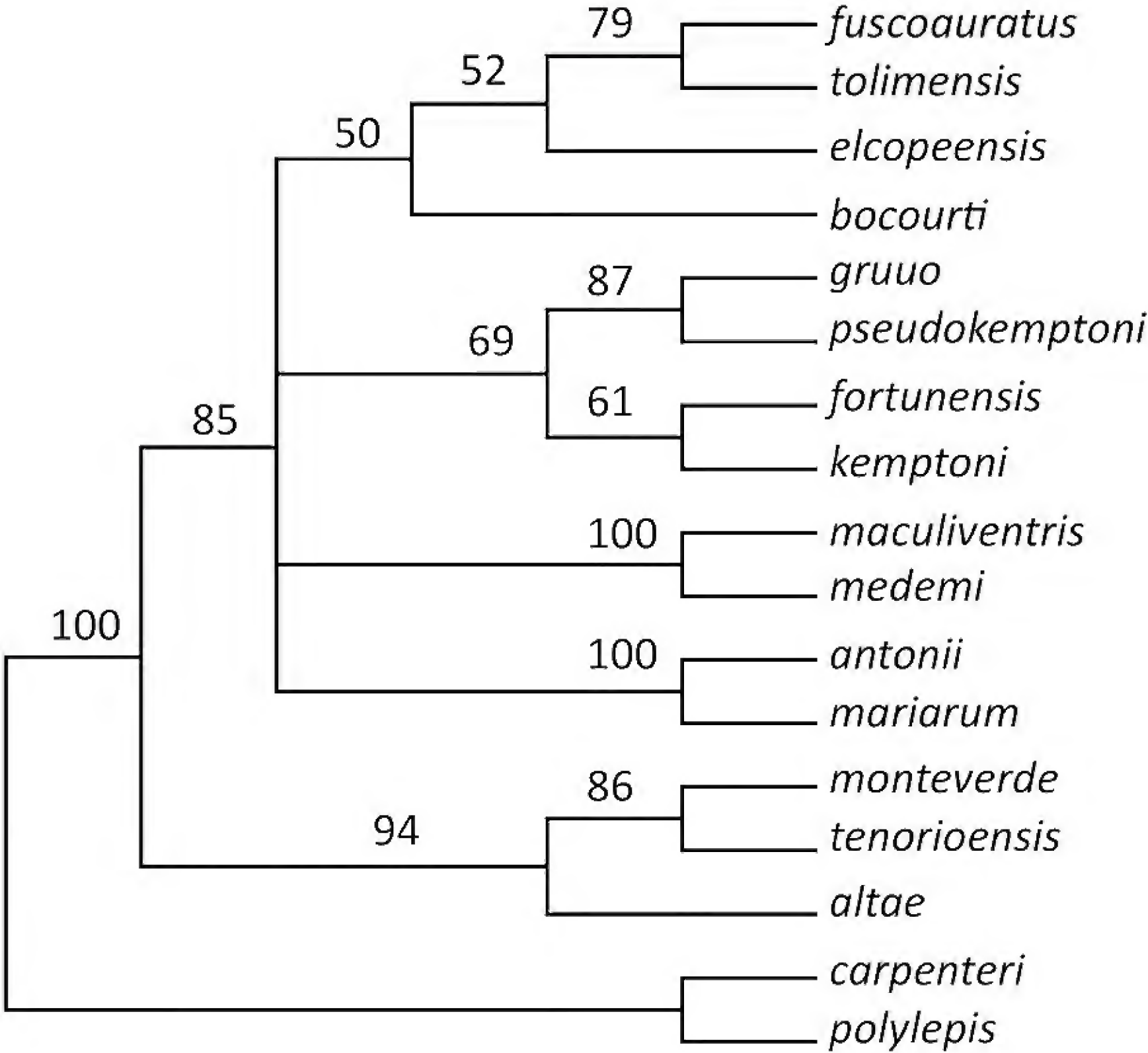


Fig. 1. Phylogenetic estimate of placement of *A. elcopeensis* sp. nov. based on Bayesian analysis of morphological and molecular data. Numbers are clade credibility values.

We also performed phylogenetic analysis of the mitochondrial COI gene for multiple individuals of the putative new species and single individuals of close relatives according to the above analysis (Appendix 1). Data were from the Barcode of Life initiative (see www.barcodeoflife.org for data collection techniques) and published data. We used Partitionfinder (Lanfear et al. 2012) to identify a best model for this gene and assigned “mixed” GTR models with rate heterogeneity to each partition. We ran the analysis for 2,000,000 generations, sampling every 1,000 trees, and discarded the first 50% of samples as burnin.

Statistical analyses

Among geographically proximal forms, the new species is most similar to *Anolis gruuo* in external morphology (see below). In order to test the distinctiveness of the hypothesized new species relative to this form, we performed a discriminant function analysis of 14 individuals of the new species and three individuals of *A. gruuo* using 10 characters of scalation, with a-priori grouping of individuals as either *A. gruuo* (individuals from Santa Fe, Veraguas, Panama; Lotzkat et al. 2012) or the putative new species (individuals from near El Copé, Penonome, and El Valle; Coclé; see below; Table 1). Characters in-

corporated were number of scales across the snout at the second canthals (snsc), number of scales between supra-orbital semicircles (sosc), number of scales between interparietal and supraorbital semicircles (ipsosc), number of postrostrals (pr), number of postmentals (pm), number of loreal rows (lorr), number of supralabials from rostral to center of eye (sle), number of expanded lamellae on fourth toe (lm), number of ventral scales counted longitudinally in 5% of snout to vent length (v5), and number of dorsal scales counted longitudinally in 5% of snout to vent length (d5). We observed no consistent differences in these traits between males and females and therefore pooled sexes in the analysis.

Results

The phylogenetic analysis of *fuscoauratus* group *Anolis* placed the putative new species with South American species *A. fuscoauratus* and *A. tolimensis* with weak support (Fig. 1). There was strong support (probability = 85%) for the new species clustering with a clade separate from species similar to *A. altae* (i.e., *A. altae*, *A. monterverde*, *A. tenorioensis*) within the *fuscoauratus* group clade.

The Partitionfinder analysis of the COI dataset suggested two partitions, one for amino acid positions one

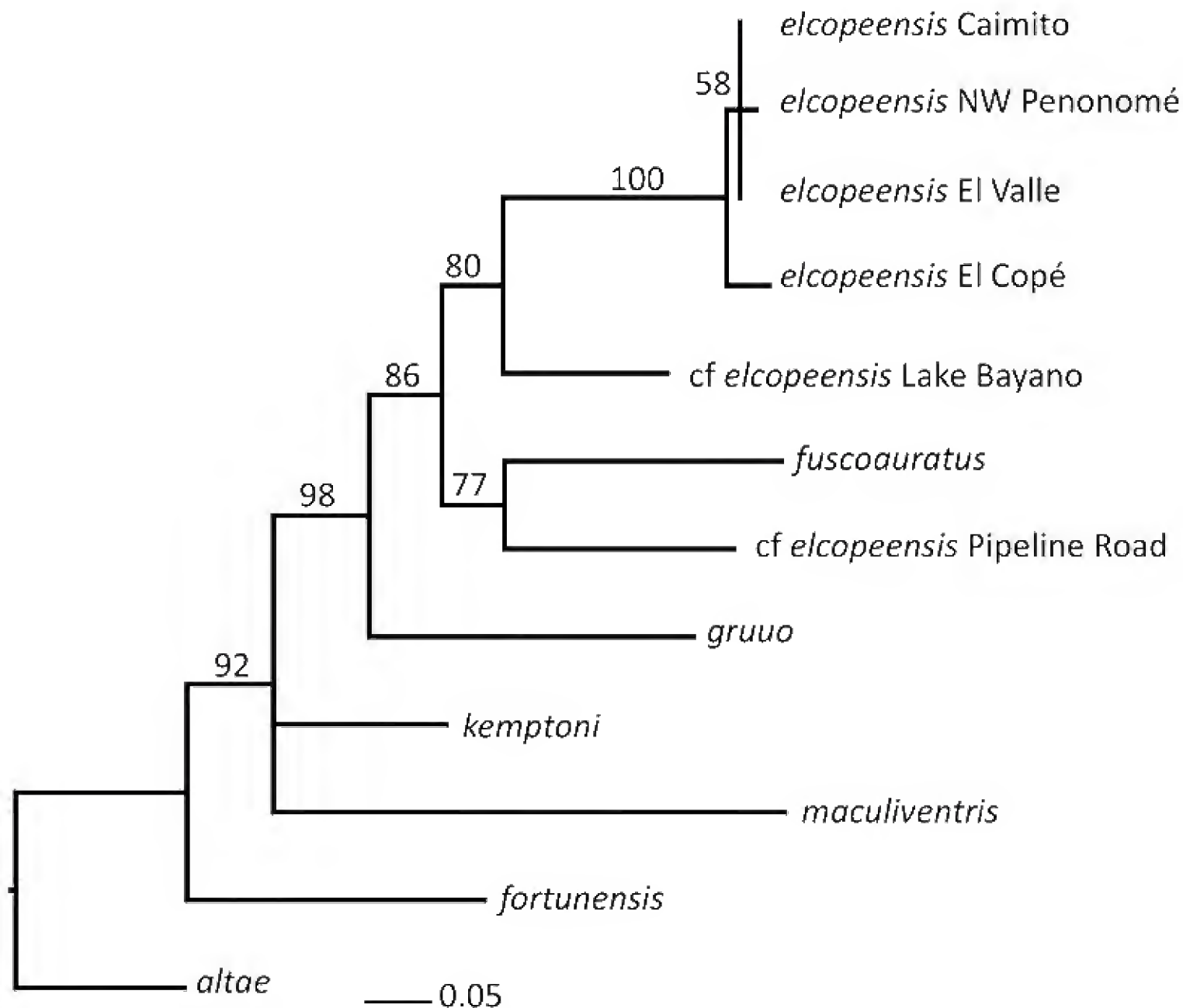


Fig. 2. Phylogenetic estimate of the mitochondrial COI gene for samples of *A. elcopeensis* and close relatives based on Bayesian analysis. Numbers are clade credibility values.

Table 1. Specimens and data used in Discriminant Function Analysis (svl listed for reference; not used in dfa). See text for abbreviations.

Species	Museum number	snscl	soscl	ipsoscl	pr	lorr	sle	pm	d5	v5	lm	svl
<i>elcopeensis</i>	MSB 95543	11	3	2	6	5	8.5	5	10	8	14.5	41.9
<i>elcopeensis</i>	MSB 95544	12	2	4	6	5	9.5	5	12	8	15.5	38.8
<i>elcopeensis</i>	MSB 95545	11	2	3	7	5	7.5	4	13	9	16	36.0
<i>elcopeensis</i>	MSB 95546	11	1	3	6	4	8	4	9	9	13.5	37.0
<i>elcopeensis</i>	MSB 95547	14	2	4	7	5.5	9.5	6	11	8	14	35.5
<i>elcopeensis</i>	MSB 95548	13	2	4	6	5	7.5	6	12	9	14	33.5
<i>elcopeensis</i>	MSB 95549	13	2	3	7	5	8	6	10	9	14	41.8
<i>elcopeensis</i>	MSB 95550	11	3	4	6	4.5	9	6	15	10	14	41.9
<i>elcopeensis</i>	MSB 95551	12	2	5	7	5	8.5	7	12	11	14	42.1
<i>elcopeensis</i>	MSB 95552	10	1	3	7	5.5	8	6	13	9	14.5	39.2
<i>elcopeensis</i>	MSB 95554	13	2	4	6	5	8	4	10	8	14	38.0
<i>elcopeensis</i>	MSB 95555	15	2	3	7	5	8	6	10	8	13.5	42.3
<i>elcopeensis</i>	MSB 95556	11	2	4	6	4	8	6	11	9	14	41.4
<i>elcopeensis</i>	MSB 95557	13	1	4	6	5	8	6	12	9	13.5	44.5
<i>A. elcopeensis</i> mean		12.1	1.9	3.6	6.4	4.9	8.3	5.5	11.4	8.9	14.2	39.6
<i>gruuo</i>	POE 1626	9	1	3	6	4.5	9.5	8	7	8	13.5	45.0
<i>gruuo</i>	POE 1627	9	3	4	6	5	8.5	6	9	9	16	43.1
<i>gruuo</i>	POE 1628	10	2	4	7	4.5	8	6	8	10	14	43.1
<i>A. gruuo</i> mean		9.3	2.0	3.7	6.3	4.7	8.7	6.7	8.0	9.0	14.5	43.7

and two and a second partition for position three. The resulting tree (Fig. 2) shows substantial divergence of the putative new species. A mitochondrial clade composed of individuals from Parque Omar Torrijos, El Valle, and two localities near Penonome is minimally divergent among populations (0.2–1.4% p distances) and at least 7.3% divergent from other included *Anolis* species. We consider these populations, which are uniform in male dewlap color, to inhabit the holotype and paratype localities of our putative new species and we describe this form below. We also discuss the other two samples (from Pipeline Road near the Panama Canal Zone and Lake Bayano) that show substantial divergence from included *Anolis*.

The discriminant function analysis accurately classified 100% of *A. gruuo* and 100% of the putative new species.

Systematics

Anolis elcopeensis sp. Nov

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Figs. 3A, 4A–B, 5A, 6.

Holotype

MSB 95571, adult male from Parque Nacional G.D. Omar Torrijos H., Coclé Province, Panama (8.66815,

-80.59267, 801 m), collected by Eric Schaad on 13 December 2008 from the trails near the visitor center.

Paratypes scored for traits

MSB 95570 bears the same data as the holotype. MSB 95550-2 bear the same locality data as the holotype, collected by Steven Poe and Caleb Hickman in December 2003. MSB 95543-9, west of El Valle de Antón, road ending at Chorro Las Mozas, Coclé Province, Panama (8.859476, -80.14686, 570 m), collected by Poe and Hickman in December 2003. MSB 95554-7, 95560-1, same west of El Valle de Anton locality, collected by Poe, Erik Hulebak, and Heather MacInnes during 30 July–4 August 2004. MSB 95559, Hotel Campestre, El Valle de Antón, Coclé Province, Panama (8.6129, -80.1251, 617 m), collected by Poe, Hulebak, and MacInnes on 31 July 2004.

Additional topotypical paratypes

MSB 95569, 95572-9 bear the same data as the holotype, collected by Schaad during December 2008.

Diagnosis

Anolis elcopeensis is a small grayish-brown anole with smooth ventral scales and short limbs. We diagnose this species relative to its 11 closest relatives (Fig. 1). *Anolis elcopeensis* is unlikely to be confused with *A. fuscoauratus* (Amazon basin; solid pink male dewlap), *A. bo-*

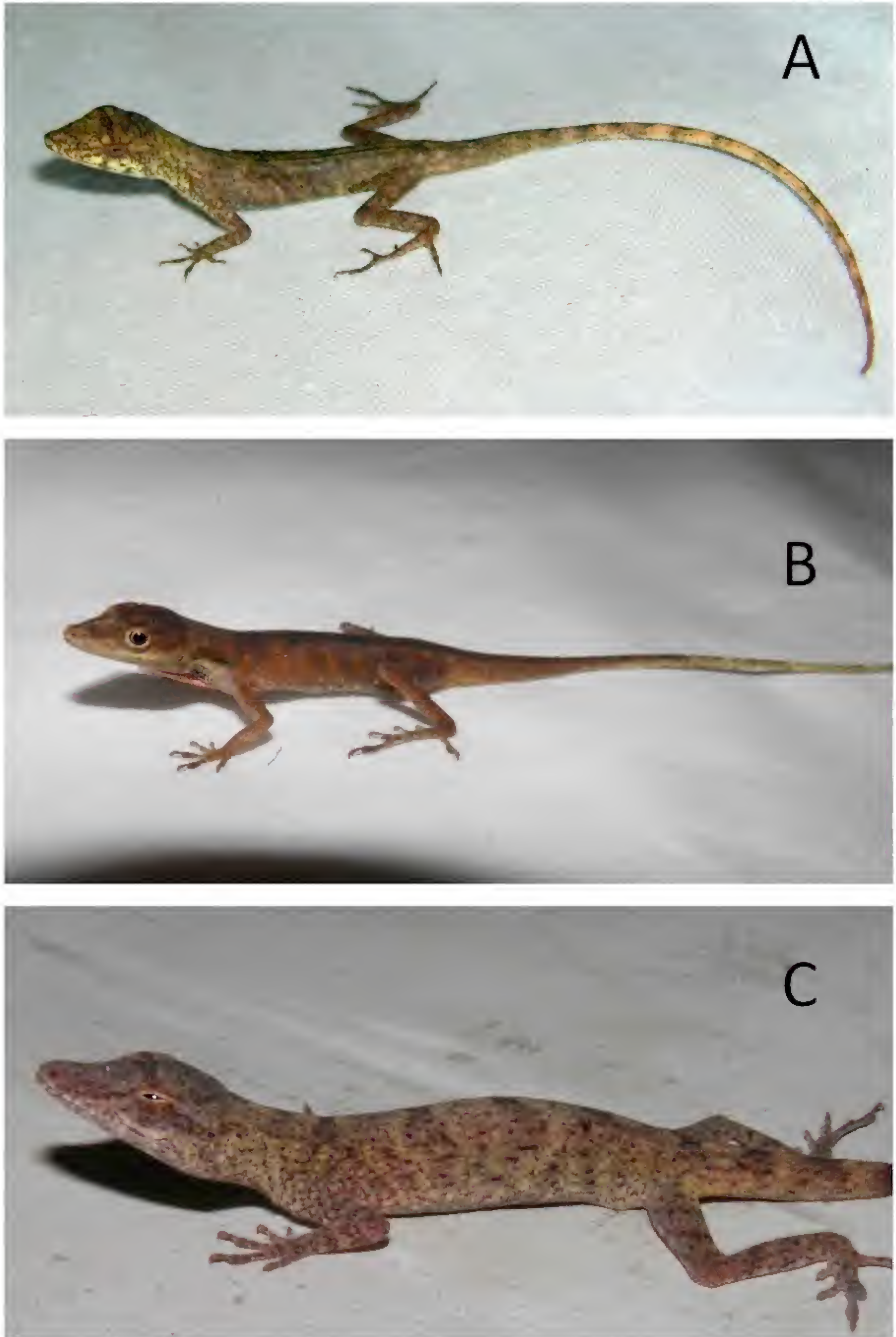


Figure 3. **A)** *Anolis elcopeensis* (female, El Copé, Coclé, Panama). **B)** *A. cf. elcopeensis* (male, south of Gamboa, Panamá, Panama). **C)** *A. cf. maculiventrīs* (female, Yaviza, Darién, Panama).



Figure 3 (continued). D) *A. maculiventris* (male, near Buenaventura, Colombia).

courti (Amazon basin; white male dewlap), *A. tolimensis* (northeastern Andes; pink and orangish-red male dewlap), *A. medemi* (Gorgona Island, Colombia; pink and orange male dewlap), *A. antonii* (northwestern Andes; pink and reddish-orange dewlap), or *A. mariarum* (extreme northwestern Andes; orange-red and yellow dewlap) based on geography. Nevertheless, *A. elcopeensis* differs from each of these species in its solid orange male dewlap color pattern.

Anolis elcopeensis is most easily distinguished from the Central American members of its clade by male dewlap color (Fig. 4; except for *A. gruuo*) and smaller body size (maximum SVL = 45 mm, $n = 35$): *A. gruuo* (solid orange male dewlap; maximum SVL = 52 mm); *A. pseudokemptoni* (red-orange anterior, pink posterior male dewlap; maximum SVL = 55 mm); *A. kemptoni* (red-orange anterior, pink posterior male dewlap; maximum SVL = 53 mm); *A. fortunensis* (red anterior, orange posterior male dewlap; maximum SVL = 49 mm).

In the field *A. elcopeensis* is most likely to be confused with *A. gruuo* and *A. carpenteri*, which have similar solid orange male dewlaps (*A. altae*, which also is similar, does not occur in Panama); and *A. limifrons* and *A. gaigei*, with which it is frequently sympatric (*Anolis elcopeensis* is amply genetically distinct from each of these species; Figs 1, 2; *A. gaigei* is phylogenetically very distant from the *fuscoauratus* group, data not shown). In addition to being larger, male *A. gruuo* display an externally bulging tailbase in our photos, presumably indicating larger hemipenes, which we did not observe in male *A. elcopeensis* (Fig. 5). *Anolis gruuo* is found at mid to high elevations (860–1,530 m) of the Serrania Tabasara from Santa Fe west 80 km to just past Hato Chami (Lotzkat et al. 2012). We found *Anolis elcopeensis* at mid to low elevations (245–801 m) from El Copé east to Altos de Campana and possibly further (see below). *Anolis carpenteri* has a dorsal greenish tint and we have observed

it to become patterned only when stressed. *Anolis elcopeensis* is never green, and usually displays banding on the tail and a dark interorbital bar regardless of mood. *Anolis carpenteri* is found on the Caribbean slope at mid to low elevations. All of our collections of *A. elcopeensis* are on the Pacific slope. *Anolis elcopeensis* and *A. limifrons* differ in male dewlap color (solid orange in *A. elcopeensis*, dirty white with or without basal yellow spot in *A. limifrons*). Females of these frequently sympatric species may be distinguished by limb length. The adpressed hindlimb of *A. elcopeensis* usually reaches to the ear, whereas in *A. limifrons* the hindlimb is longer, reaching anterior to the eye. *Anolis elcopeensis* and *A. gaigei* differ in the condition of the ventral scales (strongly keeled in *A. gaigei*; smooth in *A. elcopeensis*).

Etymology

The name honors the type locality, Parque Nacional G. D. Omar Torrijos H., and the people who have worked to maintain this wonderful forest. The park previously was named P. N. El Copé. Several new species of *Anolis* recently have been described from the park (i.e., *A. kunayalae*, *A. ibanezi*, *A. elcopeensis*).

External description of holotype (paratype variation in parentheses, measurements in mm)

Snout to vent length 43.5 (males to 44.6; females to 44.4); head length 0.23 SVL (0.22–0.26 SVL); head width 0.14 SVL (0.13–0.15 SVL); femoral length 0.25 SVL (0.25–0.28 SVL); ear height 0.03 SVL (0.02–0.03 SVL); tail length 1.7 SVL (1.5–1.7 SVL); fourth toe length 0.17 SVL (0.13–0.17 SVL).

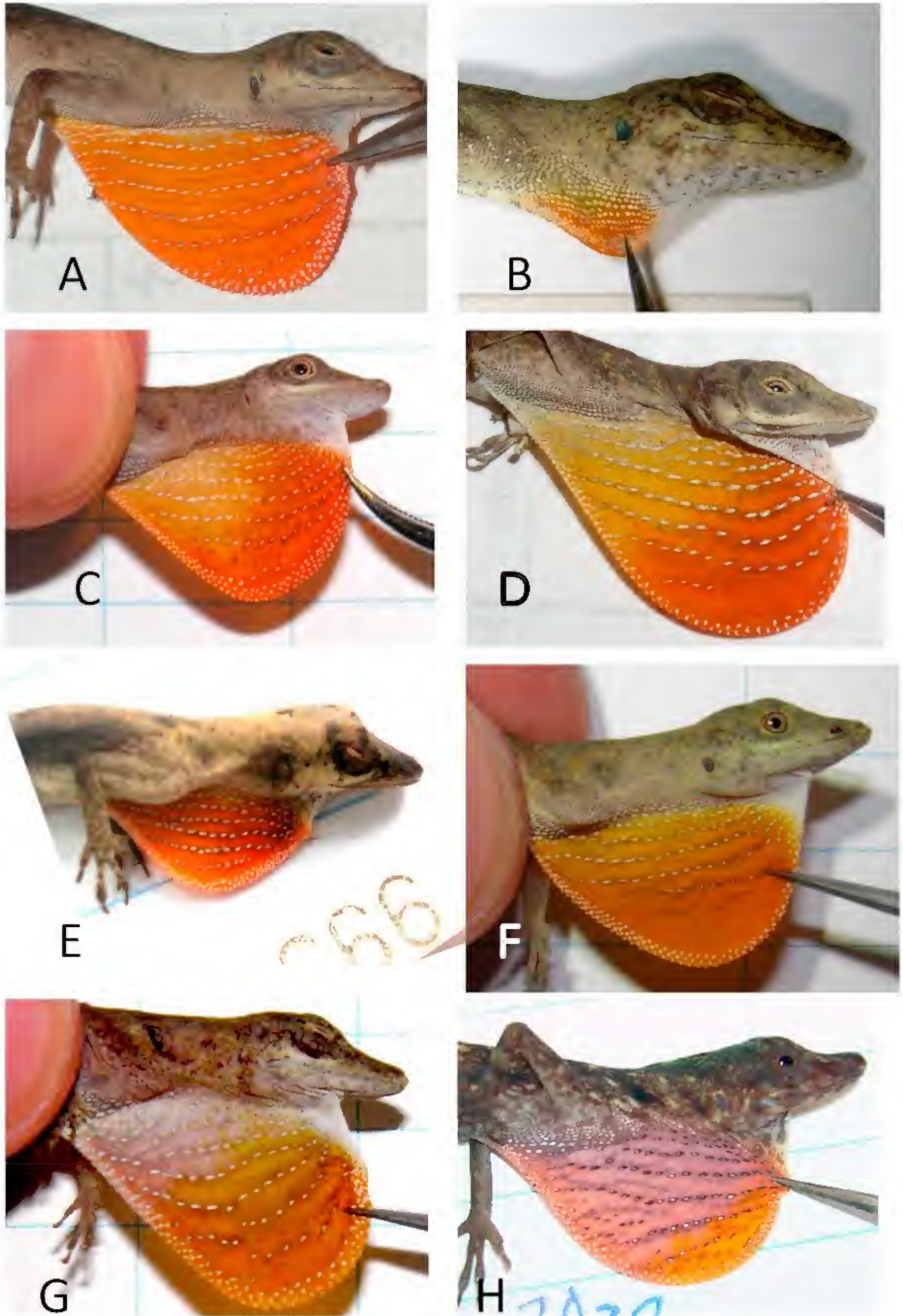


Figure 4. A) *Anolis elcopeensis* (male dewlap, El Valle de Antón, Coclé, Panamá). B) *Anolis elcopeensis* (female dewlap, El Copé, Coclé, Panamá). C) *A. cf. elcopeensis* (male dewlap, south of Gamboa, Panamá, Panamá). D) *A. cf. elcopeensis* (male dewlap, Cerro Azul, Panamá, Panamá). E) *A. cf. elcopeensis* (male dewlap, Lake Bayano, Panamá). F) *A. cf. elcopeensis* (male dewlap, Metetí, Darién, Panamá). G) *A. cf. maculiventris* (male dewlap, Yaviza, Panamá). H) *A. maculiventris* (male dewlap, near Buenaventura, Colombia).



Figure 5. **A)** *Anolis elcopeensis* (male, El Copé, Coclé, Panama). **B)** *A. gruuo* (male, Hato Chami, Chiriquí, Panama). Note bulging tail base in *A. gruuo*.

Dorsal head scales multicarinate on frontal area and uni- to multicarinate on nasal area, mostly unicarinate in supraocular disc, some smooth scales between supraorbital semicircles and posterior to orbits (or frontal and supraocular areas nearly smooth); frontal depression present; dorsal surface of rostral scale smooth, not notched; thirteen (10–14) scales across the snout between second canthals; supraorbital semicircles distinct, separated by three (1–3) scales; three (2–5) scales separate interparietal and supraorbital semicircles; supraocular disk with some enlarged scales, bordered by a complete row of small scales; one elongate supraciliary scale followed by a series of small scales; seven (4–7) loreal rows; greater than 35 total loreals; elongate anterior nasal scale contacts sulcus between rostral and first supralabial (or nasal not greatly elongate); preoccipital absent; seven (6–9) supralabials to center of eye; six (4–7) postrostrals; 6 (4–8) postmentals; gradually enlarged scales in supraocular disc; mental completely (or partially) divided posteriorly, extends posterolaterally beyond rostral (or nearly even

with sulcus), with posterior border in concave arc (or straight line transverse to head); sublabials weakly enlarged, not much larger than medial scales; dewlap large, reaching posterior to axillae (proportionately smaller in small males; variable in females: absent or small, to axillae); six-seven rows of single scales on male dewlap; tubelike axillary pocket absent; enlarged postcloacal scales present (or absent in all females and some males); nuchal, dorsal, and caudal crests absent; dorsal scales keeled; approximately two (0–3) enlarged middorsal rows; twelve (9–15) longitudinal scale rows in 5% of SVL; ventral scales smooth, in transverse rows; eleven (8–11) longitudinal scale rows in 5% of SVL; anterior thigh scales large, keeled, becoming smaller and smooth posteriorly; supradigitals multicarinate; toepads expanded and overlap first phalanx; fifteen (13–16) expanded lamellae under third and fourth phalanges of fourth toe (counted using the approach of Williams et al., [1995]); tail with single row of keeled middorsal scales.

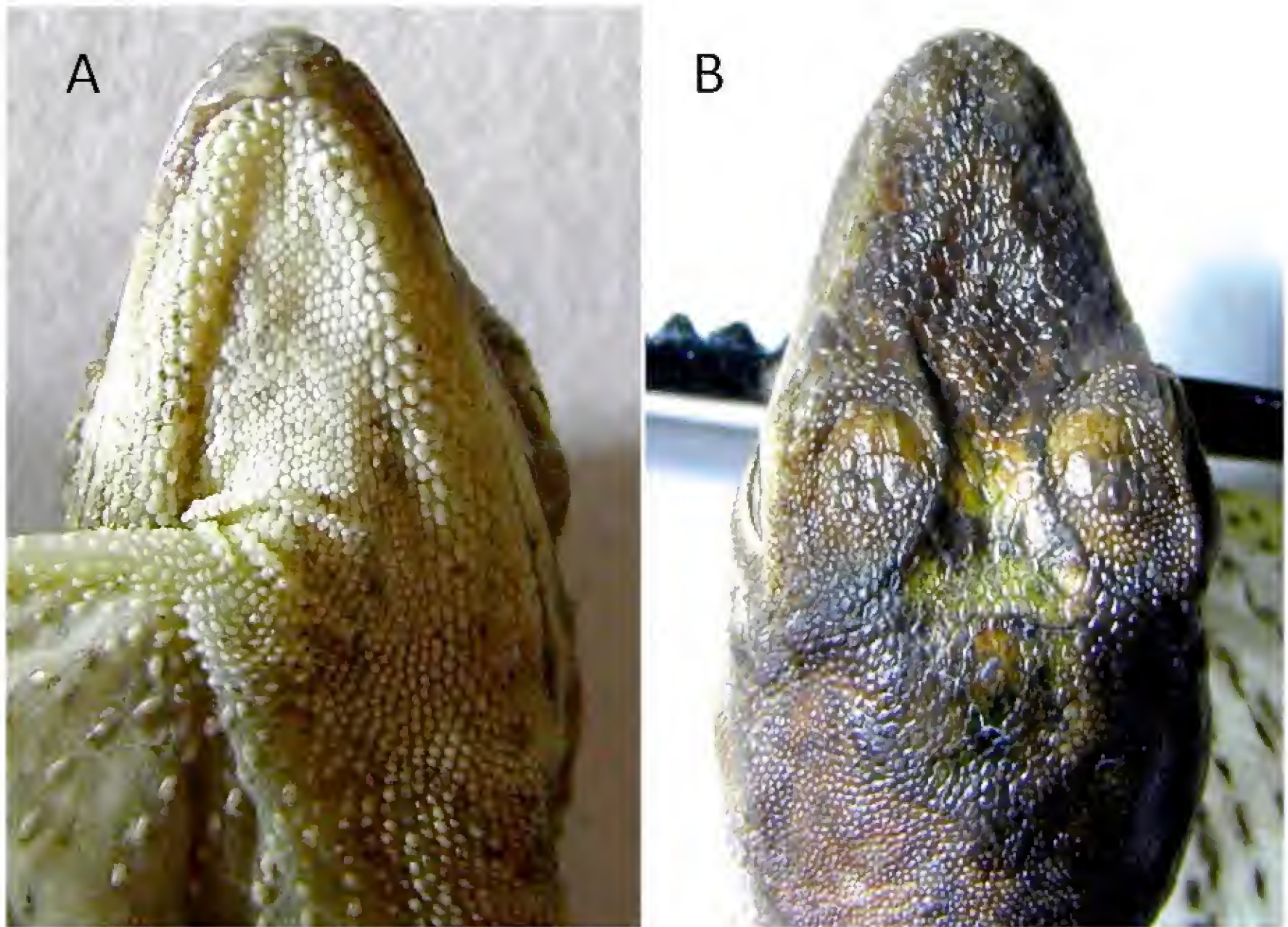


Figure 6. A) Ventral and B) dorsal head scales of holotype of *A. elcopeensis*.

Skeletal description (based on dry skeletons MSB 95560-1)

Parietal roof slightly convex, with Y-shaped parietal crests with a short stem, with no casquing, lacking crenulation on edges, with anterolateral corners flush with posterolateral edges of frontal; posterior roof of parietal slopes inferiorly; supraoccipital crests completely visible dorsally (no “half-funnel”); pineal foramen extends posteriorly into parietal, forming a U that opens at the parietal-frontal suture; dorsal skull bones smooth; post-frontal present, appears partially fused; prefrontal separated from nasal by anterior extension of frontal; frontal sutures anteriorly with nasals; no parallel crests on nasals; external nares bordered posteriorly by nasals; premaxilla dorsally nonoverlapping, laterally flush with nasals; dorsal aspect of jugal terminates on lateral or posterior surface of postorbital; posterior aspect of jugal slightly convex; epipterygoid contacts parietal dorsally; pterygoid and palatine teeth absent; lateral edge of vomer is smooth, without posteriorly directed lateral processes; maxilla extends posteriorly beyond ectopterygoid on ventral surface of skull; crest between basisphenoid processes of basisphenoid absent; lateral shelf of quadrate absent; black pigment is present on parietal only; posteriormost mandibular tooth is posterior to anterior mylohyoid foramen; splenial absent; ventral aspect of anteromedial process of coronoid juts posteriorly or slopes

smoothly anteriorly; external opening of surangular foramen bordered by both dentary and surangular; posterior suture of dentary blunt or pronged; anteriormost aspect of posterior border of dentary is well within mandibular fossa; labial process of coronoid present; coronoid does not extend posterolaterally beyond surangular foramen; jaw sculpturing absent; angular absent; teeth unicuspid anteriorly, tricuspid posteriorly; angular process of articular present; ten premaxillary tooth positions.

Color in life (adapted from field notes and color photos by SP)

Anolis elcopeensis is a brown or brownish-gray lizard. Its dorsum may be marked with faint lateral banding, rows of spotting, or striations (Fig. 3A) or appear lightly speckled (Fig. 5A), or may be nearly patternless pale gray or dark brown. The tail usually is banded, and there usually is a dark dorsal interorbital bar (Fig. 1A). The ventral body usually displays dark brown markings on white background. The iris is brown. The throat is pale.

Distribution and natural history

Anolis elcopeensis is known from Coclé Province in Panama and potentially from Panamá and Darién Provinces (Fig. 7; see below). These provinces have been

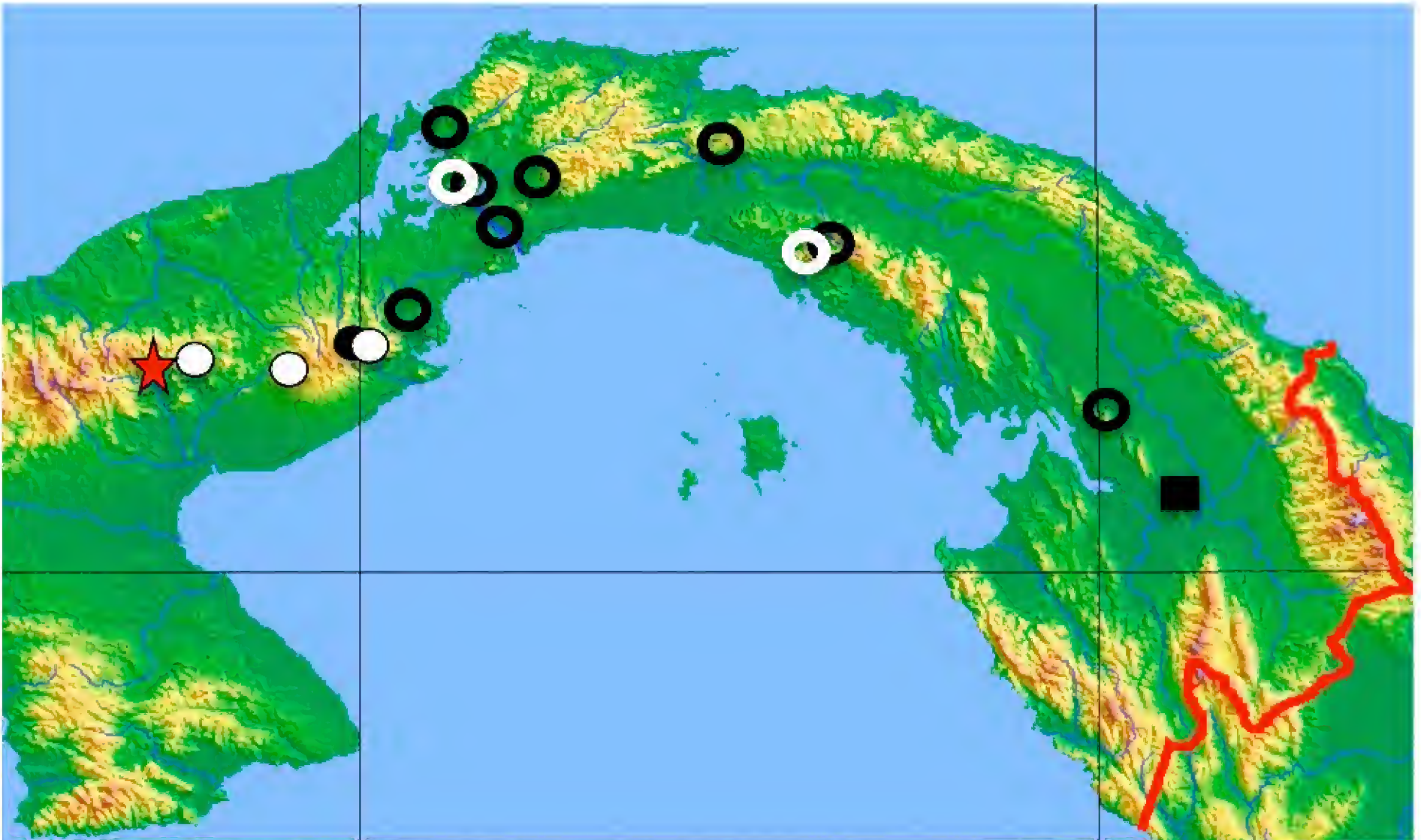


Figure 7. Map of eastern Panama showing type locality of *Anolis elcopeensis* (star; sampled for both morphology and COI), localities sampled for COI (white circles), and localities for additional specimens referenced in text (black circles). Closed circles and star indicate localities for confirmed *A. elcopeensis* according to morphological and molecular comparisons. Open circles indicate localities for specimens referred to as *Anolis cf. elcopeensis* that may represent *A. elcopeensis* or undescribed species. Square marks locality for *A. maculiventris* or a similar species (see text). Appendix 2 lists voucher specimens for localities.

well surveyed for herpetofauna, however much of Coclé is difficult to access and remains unexplored. Habitat in this province ranges from lowland rainforest in the Canal Zone up to cool tropical premontane rainforest in Parque Nacional Omar Torrijos. This range spans an elevation gradient from sea level up to over 1,000 meters. We have collected topotypical and paratopotypical *A. copeensis* from 245 to 801 meters. We have found *A. elcopeensis* in near-pristine primary and old selectively logged forests (i.e., at the type locality) and in heavily disturbed roadside vegetation.

All of our collections of *A. elcopeensis* occurred at night when anoles sleep. Among 35 recorded observations at El Copé, mean sleeping perch height was 4.15 m (standard deviation 2.35). Among 30 individuals for which sleeping perch type was recorded, 24 were on twigs, three were on leaves, and three were on vines. Thus, among perches easily surveyable by humans (i.e., excluding high canopy, burrows, etc.), narrow perches that are relatively high seem to be preferred by *A. elcopeensis*. Diurnally, the species has been observed to be active on the ground and on vegetation at heights up to 1.5 m (Mason Ryan, pers. comm.). On 23 July 2002, Ryan observed a Cocoa Woodcreeper (*Xiphorhynchus susurrans*) catching and consuming an adult male *A. elcopeensis* that was displaying from a tree buttress.

***Anolis fuscoauratus* and *A. maculiventris* in Panama?**

Anolis elcopeensis is more similar to the South American species *A. fuscoauratus* than to any species in Central America. *Anolis fuscoauratus* is a common forest anole in Amazonian South America (Avila-Pires 1995). This nondescript species is difficult to distinguish morphologically from the species described here and from its Andean and Pacific Colombian lowland congeners (*A. antonii*, *A. mariarum*, *A. tolimensis*, *A. maculiventris*, *A. medemi*), and there are doubtless multiple cryptic species among supposed *A. fuscoauratus* in Amazonia and the eastern Andes (Poe, unpublished). We have collected *A. fuscoauratus* from its type locality in Bolivia, and anoles nearly or completely indistinguishable from topotypical *A. fuscoauratus* in Peru, Colombia, Panama, and Ecuador. Some authors (e.g., Kohler 2008) list *A. fuscoauratus* from Panama, but this occurrence seems unlikely as true *A. fuscoauratus* is replaced in the western lowlands of Colombia by *A. maculiventris*.

We have collected *fuscoauratus*-like *Anolis* in eastern Panama from the Panama Canal to Pirre Station, Darién. The *fuscoauratus*-like anole we have collected along the Pan American highway out to Metetí usually possesses a bicolor orange/yellow dewlap (Fig. 4), although we

have collected specimens near Lake Bayano with solid orange dewlaps (Fig. 4E), as in *A. elcopeensis*. Although our current assignment for these eastern populations is *A. elcopeensis*, we suspect this form may represent one or multiple species distinct from *A. elcopeensis*. The variability in dewlap color (Fig. 4) and mitochondrial DNA (Fig. 2; note positions of samples from Pipeline Road and Lake Bayano) suggests the presences of a species complex of *fuscoauratus*-like anoles in central and eastern Panama. Given the local variation we have observed in limb length and body color pattern, it also is possible that we have failed to recognize multiple sympatric small grayish-brown anole species with orange dewlaps at our study sites. We currently are investigating these issues.

Near Yaviza in Darién, the *fuscoauratus/elcopeensis*-like anoles we have collected possesses a bicolor dewlap with pink posteriorly (Fig. 5G), similar to the Pacific Colombian lowland form *A. maculiventris* (Fig. 5H). In addition, some of our collections of this Darién population appeared strongly dorsally patterned (Fig. 3C), as also is common in South American *A. maculiventris* (Fig. 3D; but also occasionally evident in *A. elcopeensis* east of the canal; pers. obs.). This population may represent *A. elcopeensis* or an additional undescribed species, but for now we tentatively assign these to *A. maculiventris*. If this species inference is accurate, the number of recognized anole species in Panama is increased to 46.

Acknowledgments.—Thanks to Julie Ray and Roberto Ibañez for facilitating our field work in Panama. Caleb Hickman, Mason Ryan, Ian Latella, Julian Davis, Erik Hulebak, and Heather MacInnes helped collect individuals of the new species. Thanks to Sierra Llorona Lodge for allowing us to collect lizards on their property. Mason Ryan, Ian Latella, and three anonymous reviewers made helpful comments on the manuscript. Thanks to Gunther Kohler (SL tissue) and Omar Torres-Carvajal (QCAZ tissue) for providing tissues. Collecting and export permits were provided by ANAM. Funding was provided by the National Science Foundation.

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Appendix 1

Samples used in phylogenetic analysis of COI.

POE = field numbers of SP; MSB = Museum of Southwestern Biology; QCAZ = Museo de Zoología at Pontificia Universidad Católica del Ecuador; SL = field series of Sebastian Lotzkat. Voucher, *Anolis* species, Locality: POE 1457, *fortunensis*, Panama: Chiriquí: near Fortuna dam. POE 1474, *kemptoni*, Panama: Chiriquí: North of Boquete. SL 355, *gruuo*, Panama: Ngöbe Bugle: North of Escopeta Camp. POE 2761, *fuscoauratus*, Bolivia: Marban: Camiaco. QCAZ 4724, *maculiventris*. POE 3294, *altae*, Costa Rica: San José: Volcán Barva. MSB 95565, *elcopeensis*, Panama: Coclé: Northeast of Caimito, “La Cascada.” MSB 95566, *elcopeensis*, Panama: Coclé: 25 km NW of Penonome. POE 1894, *elcopeensis*, Panama: Coclé: Parque Nacional Omar Torrijos. MSB 95547, *elcopeensis*, Panama: Coclé: Chorro Las Mozas at El Valle. POE 1644, cf. *elcopeensis*, Panama: Panamá: Pipeline Road. POE 1665, cf. *elcopeensis*, Panama: Panamá: East of Lake Bayano.

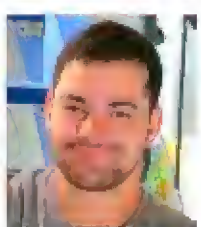
Appendix 2

Voucher specimens for referenced localities (all in Panama; see Fig. 7).

MVUP = Museo de Vertebrados, University of Panama. See Appendix 1 for other abbreviations. MVUP 2142 *Anolis* cf. *maculiventris*, Darién, 4–6 km W of Yaviza. POE 4528 *Anolis* cf. *elcopeensis*, Darién, 8 km S of Metetí. MSB 95563 *Anolis* cf. *elcopeensis*, Panama, between Rio Maje and Rio Urti E of Lake Bayano (9.0622222, -78.986111). MSB 95568 *Anolis* cf. *elcopeensis*, Panama, 11–15 km N of El Llano on El Llano-Carti Road (9.4866667, -79.026389; 463 m). MSB 95553 *Anolis* cf. *elcopeensis*, Panamá, Cerro Azul (9.22, -79.38 885 m). MSB 95562 *Anolis* cf. *elcopeensis*, Panamá, Pipeline Road north of Gamboa (9.12006, -79.71468, 44 m). MVUP 2140 *Anolis* cf. *elcopeensis*, Panamá, Radisson Summit Hotel on Gailard (9.04957, -79.63373, 130 m). MSB 95567 *Anolis* cf. *elcopeensis*, Panamá, Sierra Llorona Lodge near Santa Rita Arriba (9.342, -79.776, 200 m). MSB 95558 *Anolis elcopeensis*, Panamá, Altos de Campana (8.68, -79.94, 800 m). POE 1626–1628 *Anolis gruuo*, north of Santa Fe, Veraguas, Panama.



Steven Poe is Associate Professor in the Department of Biology and Associate Curator in the Division of Amphibians and Reptiles of the Museum of Southwestern Biology at the University of New Mexico, USA. His research focuses on taxonomy, phylogenetics, and comparative evolution, especially of *Anolis* lizards. He has collected over 250 species of *Anolis* in 15 countries.



Simon G. Scarpetta is a field conservation biologist at Stanford University and a soon to be graduate student of paleontology at The University of Texas at Austin. He received his B.S. in Biology with an emphasis in ecology and evolution from Stanford University, where he studied phylogenetics and biogeography of *Ameiva* lizards. He has also been involved with lab and field work at the University of New Mexico studying *Anolis* lizards. Simon is currently interested in osteology and evolutionary patterns of lizards in western Australia.



Eric W. Schaad is a senior associate biologist for Quad Knopf Inc. in Central California. He received his M.S. in biology at the University of New Mexico where he studied the evolution of ecomorphs and community structure in *Anolis* lizards. Eric currently works in conservation biology with a focus on reptile and amphibian conservation and the impacts of development on threatened and endangered species in Central California.

A new species of *Anolis* from Panama

In accordance with the International Code of Zoological Nomenclature new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in ZooBank (Polaszek 2005a, b), the official online registration system for the ICZN. The ZooBank publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix “<http://zoobank.org/>.” The LSID for this publication is: urn:lsid:zoobank.org:pub:22ED2728-2093-46D6-AE9B-A77AC56A7412.

Separate print-only edition of paper(s) (reprint) are available upon request as a print-on-demand service. Please inquire by sending a request to: *Amphibian & Reptile Conservation*, amphibian-reptile-conservation.org, arc.publisher@gmail.com.

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Varanus cerambonensis on the island of Buru. Photograph by Valter Weijola.



A single species of mangrove monitor (*Varanus*) occupies Ambon, Seram, Buru and Saparua, Moluccas, Indonesia

^{1,3}Valter Weijola and ^{2,4}Samuel S. Sweet

¹Zoological Museum, University of Turku, 20520 Turku, FINLAND ²Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, California 93106, USA

Abstract.—According to current literature the islands of the central Moluccan region harbor at least three species of monitor lizards. This suggests similar patterns of species richness to the northern Moluccas and could imply significant taxonomic and ecological complexity throughout the Moluccan region. Field investigations in habitats from sea level up to 300 m elevation failed to locate more than one widespread species, by definition referable to *Varanus indicus* (type locality Ambon). Reassessments of records for other species of mangrove monitors show that these can either be attributed to taxonomic mis-identifications or to colonial-era specimens lacking reliable collection data. We test Principal Components Analysis of scalation characters as a diagnostic tool for some of the island populations and species within the *Varanus indicus* group.

Key words. Monitor, *Euprepiosaurus*, *Varanus indicus*, *Varanus cerambonensis*, *Varanus rainerguentheri*, Moluccas, habitat use

Citation: Weijola V, Sweet SS. 2015. A single species of mangrove monitor (*Varanus*) occupies Ambon, Seram, Buru and Saparua, Moluccas, Indonesia. *Amphibian & Reptile Conservation* 9(1) [General Section]: 14–23 (e95).

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Introduction

The island of Ambon has had a history of commercial and strategic importance and has been connected to the European economy for five centuries. As a consequence, many early faunal collections came from there, and it is the type locality for a considerable number of Indonesian species, some of which have proved to be native to the island whereas others were merely shipped from Ambon (e.g., Daan and Hillenius 1966; Hoek Ostende et al. 1997). Despite this long European presence, little first-hand information has been published on the biology of the local *Varanus* species. The first recorded observations and possible specimen collection of monitors on Ambon were made in 1792 by Claude Riche, one of the naturalists of the d'Entrecasteaux Expedition, and reported by F.M. Daudin in the description of *Tupinambis indicus* a decade later (Daudin 1802). For the next two hundred years this was the only species reported from the central Moluccas (to which we refer to the islands of Seram, Buru, Ambon, and the other islands in the Lease group).

This changed when Philipp et al. (1999) revised the identity of *V. indicus* and described a second species

from Ambon, Seram, and Buru, which they named *V. cerambonensis* (Fig. 1 A–D), distinguishable from *V. indicus* through the presence of a yellow temporal stripe, a banded dorsum, and a bi-colored tongue. In 2012 Somma and Koch reported that a third species, *V. rainerguentheri* (Fig. 1 E–F), also occurs on Buru in sympatry with *V. cerambonensis* (and possibly *V. indicus*). *Varanus salvator* has also been reported to occur on Seram on the basis of a single voucher specimen (Koch et al. 2007). These records are discussed here and Principal Components Analysis (PCA) is tested as a tool to detect differences between island populations of species in the *V. indicus* group (Fig. 2).

With a surface area of 17,400 km² Seram is the second-largest island in the Moluccas (after Halmahera) (Monk et al. 1997). It is estimated to have emerged as a land mass around 5–6 MYA along the Outer Banda Arc and rotated westward (Hall 2002), thus always having been isolated from New Guinea (Audley-Charles 1993; Fortuin and de Smet 1991). For animal groups with good dispersal abilities, such as Lepidopterans, this appears to have had little impact on current diversity and community composition when compared to the slightly larger

Correspondence. Email: ³vweijola@gmail.com (Corresponding author); ⁴sweet@lifesci.ucsb.edu



Fig. 1. Mangrove monitors and their habitats: *V. cerambonensis* on Ambon (A), Seram (B), and Buru (C, D). *Varanus rainerguentheri* on Halmahera (E) and Obi (F). Coastal vegetation on Ambon (G) and Nipa swamp (H). Photographs by Valter Weijola.

island of Halmahera (de Jong 1998). For monitors specifically, the lack of a land connection with New Guinea appears to have restricted the number of successful colonizers to just one (this study) whereas the composite island of Halmahera has a larger set of species (Weijola 2010).

There are strong patterns in the distribution of the members of the subgenus *Euprepiosaurus*, the Indoaustralian radiation of gracile terrestrial and arboreal species containing mangrove and blue-tailed monitors and the slender tree monitors of the *V. prasinus* group. Members of the latter clade are largely restricted to landmasses on the Sahul shelf. The blue-tailed monitors in the *V. indicus* group (*V. caerulivirens*, *V. doreanus*, *V. finschi*, *V. jobiensis*, and *V. yuwonoi*) show a similar pattern, with the exceptions of also inhabiting Halmahera (and adjacent islands) as well as the island of New Britain (Ziegler et al. 2007). The only lineage with a demonstrated ability for significant oversea dispersal is that mainly inhabiting coastal areas, traditionally known as a variable and widespread mangrove monitor, *V. indicus*. This lineage, with one representative in the central Moluccas, has lately been split up into several closely related species that all appear to exhibit allopatric distributions: *V. cerambonensis* (Buru, Ambon, Lease Islands, Seram); *V. indicus* (Australia, New Guinea, and satellite islands, as well as many Pacific islands); *V. melinus* (Mangole and possibly Taliabu); *V. juxtindicus* (Rennell); *V. rainerguentheri* (northern Moluccas); *V. lirungensis* (Talaud); and *V. obor* (Sanana) (Fig. 3). Additional populations of uncertain status occur in the Aru, Kei, and Tanimbar island groups.

In 2008 to 2009 fieldwork was conducted to study the niche partitioning among monitor species on several Moluccan islands (Weijola 2010; Weijola and Sweet 2010). On Ambon, Seram, Saparua, and Buru the species communities were initially presumed to be composed of *V. indicus* utilizing coastal habitats and *V. cerambonensis* occupying habitats farther inland as suggested by Philipp et al. (1999) and mirroring the ecological roles of *V. rainerguentheri* and *V. caerulivirens* on Halmahera (Weijola 2010) or *V. indicus* and *V. jobiensis* on New Guinea (Philipp 1999). This hypothesis was rejected during fieldwork as it became evident that only one of the species, *V. cerambonensis* (*sensu* Philipp et al. 1999), functioned as a habitat generalist and occurred throughout each island, and that *V. indicus* (*sensu* Philipp et al. 1999) was absent from these islands altogether.

The absence of *V. indicus* (*sensu* Philipp et al. 1999) is problematic inasmuch as Ambon is the type locality for this species. The only two specimens, ZMA 11146c and ZFMK 70650 (formerly ZMA 11146d), indicating a sympatry between *V. indicus* and *V. cerambonensis* on Ambon (and in the central Moluccas) turned out to have belonged to a colonial-era collector stationed on Ambon, but there is no evidence to suggest that they were actually collected there. The identity of *V. indicus* has been reviewed in detail by Weijola and a Case to synonymize *V. cerambonensis* with *V. indicus* has been submitted to the

International Commission on Zoological Nomenclature (ICZN) (Weijola, *In press*). As this nomenclatural issue is yet to be resolved we follow the current name uses and diagnoses here but note that future changes are possible.

Methods

Fieldwork was conducted during March and December 2009 near the following settlements: Ambon – Liang (VW); Hitu (VW, SS); Soya di Atas (VW, SS); upper Ambon Bay (VW, SS); Waitami (VW, SS); Latuhalat (VW, SS); Seram (VW) – Besi; Buru (VW) – Namlea, Wamlana, Samleko; and Saparua (VW, SS) – Kulur. Species identification in the field followed the diagnostic characters provided by Philipp et al. (1999). Accordingly *Varanus cerambonensis* can be identified by its distinct yellow temporal band and yellow markings (dots and/or ocelli) arrayed in a pattern of transverse bands on the dorsum. These characters can effectively be used in the field even at a distance with a pair of binoculars.

Observations on habitat use were obtained by quietly traversing all major habitat types from coastal (mangroves, natural coastal scrub, coconut plantations, parklands) to lowland rainforests and hill forests up to 300 m elevation. Searches were made on foot or by canoe. For each observation date, time, location, habitat, and vegetation type, altitude, and activity were recorded. Active animals could often be heard running through dry litter in the undergrowth before fleeing up a tree where their identity could be confirmed. Basking animals often remained still unless approached within flight distance (normally 10–30 m).

The examination of museum vouchers allowed for a larger set of characters including scale counts to be assessed. According to Philipp et al. (1999) *V. cerambonensis* has on average smaller scales and higher scale counts than does *V. indicus*: e.g., scales around midbody (131–150 vs. 106–144), or transverse rows of dorsal scales (126–163 vs. 105–137).

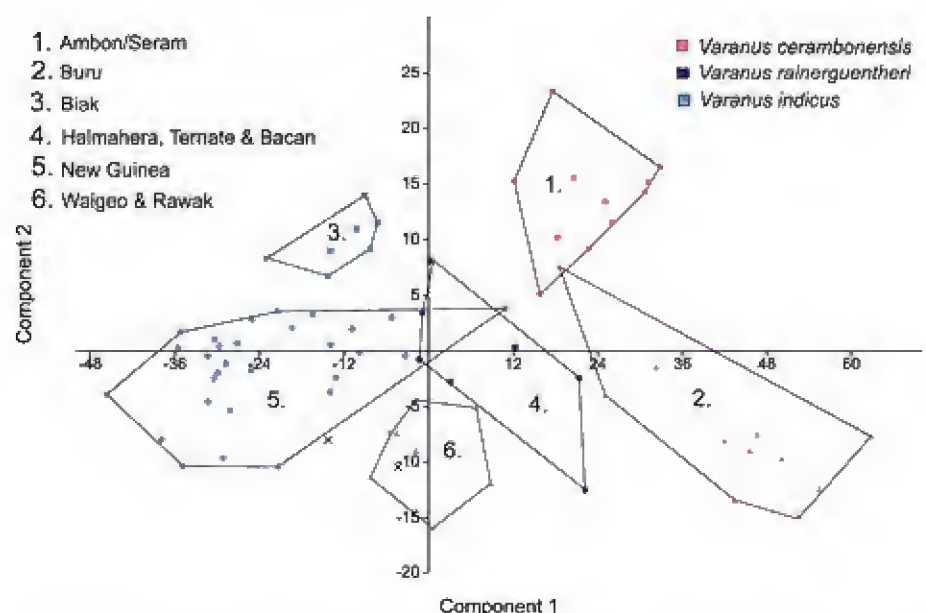


Fig. 2. Principal Components Analysis of scalation characters for several island populations of *V. cerambonensis*, *V. indicus*, and *V. rainerguentheri*. The two Xs represent ZFMK 70650 and ZMA 11146c.

Museum specimens at Naturalis (RMNH) and the Zoological Museum Amsterdam (ZMA) were identified (VW) and scale counts for a Principal Components Analysis were extracted from Brandenburg (1983). Counts employed were: midbody scale rows (S), dorsal scale rows from dorsal margin of tympanic recess to anterior margin of hind limbs (XY), transverse rows of ventral scales from gular fold to anterior margin of hind limbs (T), transverse rows of dorsal scales from posterior margin of tympanic recess to gular fold (X), scales around neck at anterior margin of gular fold (m), scales from rictus to rictus across dorsum of head (P), scales around tail base (Q), scales around the tail 1/3 from the base (R), and number of ventral scales from the tip of snout to gular fold (N).

Principal Components Analysis was performed in PAST (Hammer et al. 2001) using all the above-mentioned scale characters for specimens from Ambon, Seram, Buru, Halmahera, Ternate, Bacan, New Guinea, Waigeo, and Biak (Appendix 1).

Results

Morphology

The Principal Components Analysis of scalation characters (Fig. 2) worked well to differentiate the included island populations with partial overlap found only be-

tween *V. rainerguentheri* and *V. indicus*. PC1 and PC2 accounted for almost 90% of the total variance. The factor loadings for PC1 were all positive with highest values on factors XY (0.78) and S (0.42). On PC2 all loadings were positive except for XY and R, with highest values on T (0.71) and m (0.61). PC3 gave more overlap between the population clusters. Eigenvalues and factor loadings for PC1–PC3 are presented in Table 1.

Habitat use

All field observations, involving a total of 81 sightings (Ambon, 31, Buru, 21, Seram, 9, and Saparua, 20) were identified as *V. cerambonensis*. Monitors were most numerous on Ambon, Buru, and Saparua whereas fewer observations were made on Seram. A majority of observations ($n = 70$) was made in coastal areas where monitor population densities appear to peak. Encounter rates were high both in littoral forest ($n = 38$) in sandy and karst ($n = 9$) areas, as well as in mangroves ($n = 14$) and Nipa swamps ($n = 9$). The preferred areas usually had a bushy undergrowth used for hiding and larger trees for basking and hiding in tree cavities. Seven observations were made in coconut or mixed-crop plantations in lowland areas.

Far fewer monitors were observed in lowland rainforests ($n = 1$), swamp/sago forest ($n = 1$), and hill forests ($n = 2$), with the highest altitude observation at around 300 m near a small stream at Soya di Atas on Ambon. There

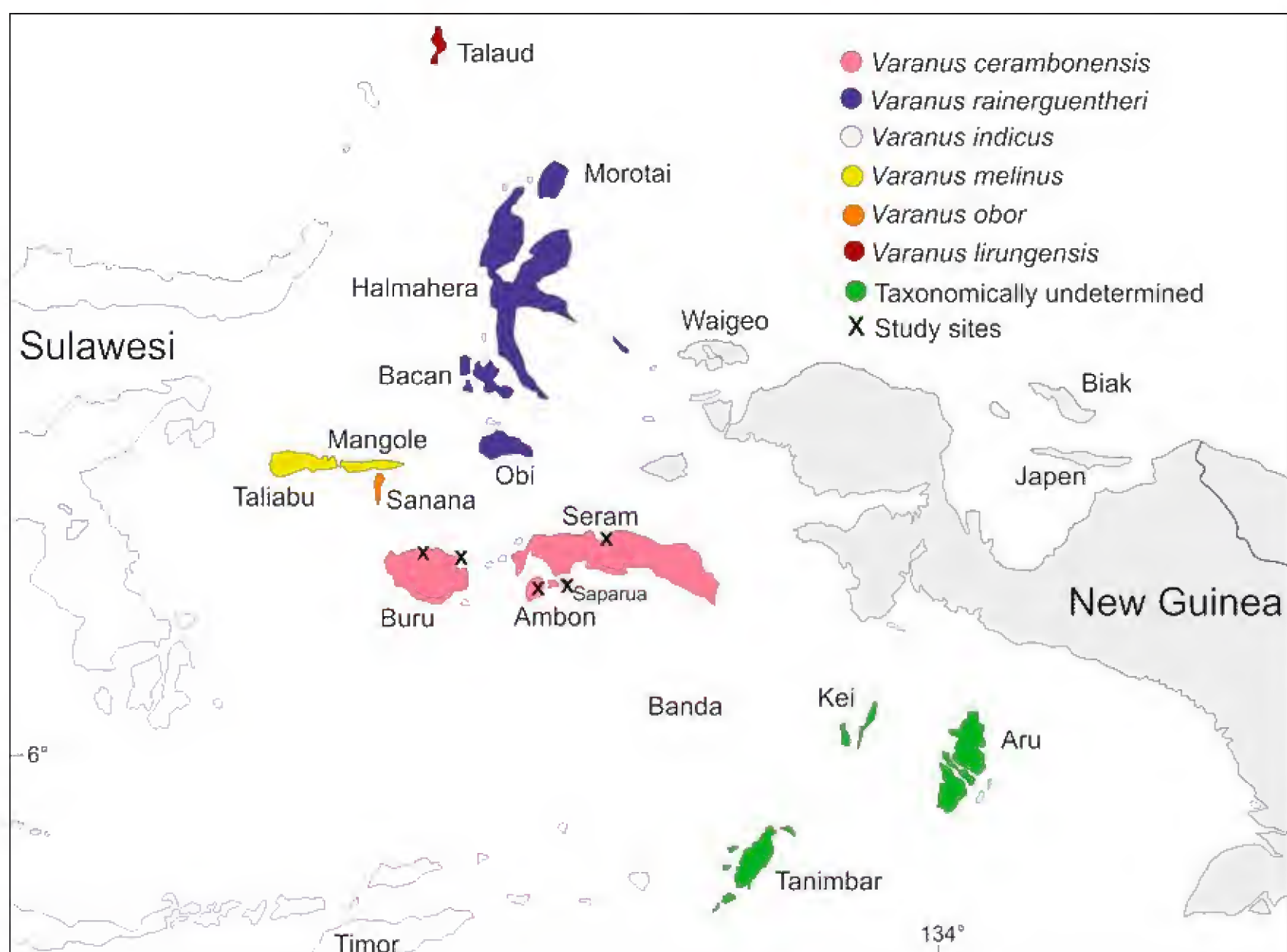


Fig. 3. Distribution map of mangrove monitors in the Moluccas and western New Guinea, the blue tailed monitors not included.

Table 1. Loading values, proportion of variance, and eigenvalues for PCA. The two highest loading factors on the three first components highlighted.

Factor	Comp 1	Comp 2	Comp 3
P	0.111204	0.099216	-0.054745
Q	0.19027	0.24899	0.3686
XY	0.77924	-0.57179	-0.10626
m	0.36133	0.60913	-0.23433
S	0.41622	0.45941	0.036529
T	0.27334	0.71204	0.1145
N	0.16643	0.10618	0.15529
R	0.0088444	-0.052658	0.8697
Proportion of variance	81.245	8.594	4.1006
Eigenvalue	711.843	75.2985	35.9281

is however an almost fully melanistic specimen (ZMA 15416g) at the Naturalis Museum collected at Lake Rana on Buru (at 770 m elevation) which shows that the species also occupy higher altitudes.

Activity and foraging

Fifty-six of the monitors were first observed while actively moving or foraging on the ground whereas the other 25 were first seen while basking on tree trunks/branches ($n = 21$) or on the ground ($n = 4$). Monitors usually became active and emerged to bask at around 0815–0845 and returned to their retreats late in the afternoon, the latest observation of an active individual was made on Ambon at 1600. The only specific foraging events observed during this study were several specimens on Buru actively digging out sea turtle nests in search of eggs, one individual on Seram digging for sago grubs in a rotten Metroxylon trunk, and another individual (also on Seram) digging through a pile of garbage at the edge of a mangrove swamp.

Discussion

Natural history

Observations of habitat use of *V. cerambonensis* correspond well with that reported from field studies of mangrove monitors (*V. indicus sensu lato*) in other regions (Iyai and Pattiselanno 2006; Philipp 1999; Smith and Griffiths 2009; Weijola 2010). Densities appear to peak in coastal and saltwater influenced areas with suitable vegetation cover and decrease with increasing altitude where animals also become more restricted to areas near bodies of freshwater. Dietary studies show *Varanus cerambonensis* to be an opportunistic predator with the single largest component being crustaceans which makes up almost half of the diet (Philipp et al. 2007). As is usual throughout the Moluccas monitors were more frequently

encountered near Muslim than Christian settlements, presumably reflecting dietary restrictions and the scarcity of hunting dogs.

In more species rich-communities such as that of Halmahera, mangrove monitors (on Halmahera *V. rainerguentheri*) are rarely observed at higher altitudes where instead *V. caerulivirens* is common (Weijola 2010). *Varanus indicus* on New Guinea may similarly be restricted in upland areas by competition from *V. jobiensis* and *V. doreanus*. On some single species islands the mangrove monitors appear to persist higher up and can occasionally be found up to at least 700–900 m elevation (as demonstrated by their presence at Lake Rana on Buru). On New Ireland, Papua New Guinea, the senior author has collected mangrove monitors as high up as the Lelet Plateau at 900 m elevation (Weijola, *unpub. data*).

Biogeography

Whereas many of the larger islands in the northern Moluccas (e.g., Halmahera, Obi, Bacan, and Morotai), and island arcs moving along the northern coast of New Guinea, have several monitor species with evident ecological specialization (Weijola 2010), the other Moluccan islands, including Ambon, Seram, Buru, Tanimbar, and Kei, have only single members of ecological generalists of the *V. indicus* group present (this study; Weijola, *unpub. data*). These are joined by members of the *V. salvator* group in the Sula islands and on Obi (Weijola 2010; Weijola and Sweet 2010), but the presence of *V. salvator* on Seram (Koch et al. 2007) has not gained support from recent fieldwork (Edgar and Lilley 1993; this study) and they were unknown to several experienced hunters contacted by VW. This is usually a conspicuous animal wherever it occurs; for example, the new records for Taliabu and Sanana were established on the first and second days of fieldwork (VW and SS), on the first day on Mangole (VW) and on the second day on Obi (VW).

Varanus rainerguentheri

Somma and Koch's (2012) distribution record of *V. rainerguentheri*, and their claim of its co-existence with *V. cerambonensis*, on Buru is based on a preserved specimen (Senckenberg Museum, Frankfurt [SMF 56469]) and a photo taken in the field (Somma and Koch 2012, Fig. 6). Both were identified as *V. rainerguentheri* from the occurrence of rows of dorsal ocelli. However, there are eleven vouchered *Varanus* from Buru at the Naturalis Museum (ZMA 15416a–j, RMNH 7223), which are similar in color pattern to those presented as *V. rainerguentheri* by Somma and Koch, and which were examined and identified as *V. cerambonensis* by Philipp et al. (1999) (forming the record of *V. cerambonensis* for that island). All above-mentioned specimens conform in color pattern to those observed in the field during this study. As is indicated by Weijola (2010) there are typically no

distinct bands of dorsal ocelli on adult *V. rainerguentheri* but these are instead characteristic of the *V. cerambonensis* populations on Ambon and especially Buru (ZMA 15416, Weijola field observations). For these reasons we regard Somma and Koch's records of *V. rainerguentheri* from Buru to be mis-identifications of *V. cerambonensis*.

Principal Components Analysis

The results of the PCA illustrates its potential to recover geographic clusters among the sampled islands. As the increasing number of island endemics and cryptic species has made identifications more problematic, and the use of single color pattern characteristics can be misleading, we acknowledge its usefulness as an additional diagnostic tool.

Although considered conspecific the distance between the Ambon/Seram and Buru populations detected by the PCA indicate morphological separation between the two populations. In addition to scalation differences the population of Buru also differ in color pattern from those of Ambon and Seram, notably by the brown/orange throat and abdomen color (seen in live specimens), as well as having more evident dorsal rosettes.

Conclusions

Recent research on Indonesian monitors has relied heavily on colonial-era museum voucher specimens and recent animals obtained from the pet-trade (Böhme and Ziegler 1997; Philipp et al. 1999; Somma and Koch 2012; Ziegler et al. 2007a, b). This has obscured the fact that some of the newly described island endemics such as *V. melinus*, *V. cerambonensis*, and *V. rainerguentheri*, are not previously unknown animals co-occurring with a widespread *V. indicus*, but are instead local forms previously assigned to a variable *V. indicus* that have now been recognized as separate taxa. This has inflated the number of species thought to be present, with several islands allegedly harboring multispecies communities. Although we cannot rule out the possible existence of additional secretive species we conclude that there currently is no evidence for more than one species of mangrove monitor in the central Moluccas.

To avoid future confusion in the taxonomic and biogeographic interpretations of this group we call for more critical scrutiny of unique colonial-era museum specimens with single-word localities and no further supporting information.

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Valter Weijola has a B.S and M.S in biology from Åbo Akademi University and is now a Ph.D. student at the University of Turku. He is currently working on the biogeography and phylogenetics of Pacific monitors and has traveled extensively in Indonesia, Papua New Guinea, and the Solomon islands in pursuit of his interests.



Sam Sweet received a B.S. at Cornell University, and M.S. and Ph.D. at the University of California, Berkeley. He is Professor of Ecology and Evolution at the University of California Santa Barbara, and divides his time between recovery efforts for endangered herpetofauna in southwestern North America, and investigations of the spatial ecologies of Indoaustralian monitor lizards.

Appendix 1**Naturalis Museum specimens and scalation data included in the PCA.**

Catalog number	Island	P	Q	XY	m	S	T	N	R
ZMA 10202	Alkmaar Island	44	78	134	82	131	90	75	60
RMNH 7297a	Ambon	48	89	150	105	140	96	86	56
RMNH 7297b	Ambon	47	81	146	100	140	95	83	52
RMNH 7297d	Ambon	52	85	152	104	142	94	84	54
RMNH 7297e	Ambon	48	80	139	104	138	93	81	51
RMNH 7297f	Ambon	51	79	148	101	131	95	79	50
RMNH 7297g	Ambon	50	87	153	105	146	100	85	53
RMNH 7196	Ambon	51	88	149	96	141	96	88	57
RMNH 3152	Ambon	51	89	154	110	143	100	90	56
RMNH 3150	Ambon	54	82	138	110	142	97	86	49
RMNH 3800	Bacan	42	80	134	88	128	91	85	57
RMNH 21031g	Biak	40	80	125	92	131	87	83	64
RMNH 21031h	Biak	39	79	124	94	128	86	77	61
RMNH 21033	Biak	42	76	122	92	135	86	81	62
RMNH 21026a	Biak	37	78	127	94	128	83	82	60
RMNH 21026b	Biak	37	80	121	88	126	86	84	61
RMNH 21024	Biak	38	74	115	88	122	84	77	58
RMNH 21021	Biak	42	79	123	90	122	85	79	64
RMNH 7223	Buru	46	79	147	95	145	95	78	55
ZMA 15416a	Buru	46	84	192	104	151	104	84	58
ZMA 15416b	Buru	46	83	187	95	141	104	86	58
ZMA 15416c	Buru	49	93	178	94	138	103	85	60
ZMA 15416d	Buru	48	88	187	90	150	100	90	68
ZMA 15416e	Buru	48	83	179	99	142	100	85	58
ZMA 15416f	Buru	46	85	183	98	143	101	83	54
ZMA 15416g	Buru	44	82	164	96	143	96	81	52
ZMA 15416h	Buru	47	83	174	93	142	103	86	60
ZMA 15416i	Buru	52	82	179	94	135	105	81	49
ZMA 15416j	Buru	44	75	159	91	142	95	81	53
ZMA 15414a	Halmahera	38	77	163	90	128	91	91	56
ZMA 15414b	Halmahera	43	82	155	89	139	93	85	61
ZMA 15414c	Halmahera	42	80	147	92	132	91	87	60
RMNH 7197	Haruku	46	89	144	101	142	97	88	50
RMNH 21041	Insoemarr Island	41	74	120	86	121	79	74	53
RMNH 21045	Japen	39	66	107	85	106	76	67	45
RMNH 21052	Japen	38	69	105	79	120	81	69	45
RMNH 21053	New Guinea	39	75	113	71	107	74	76	56
RMNH 21054	New Guinea	38	63	105	75	108	73	73	50
RMNH 21055a	New Guinea	41	70	111	83	109	77	74	56
RMNH 21047	New Guinea	40	73	115	79	113	85	77	57
RMNH 21042	New Guinea	43	70	115	83	113	79	76	52
RMNH 21046	New Guinea	39	76	110	81	110	77	77	58
RMNH 21036a	New Guinea	40	70	116	78	110	80	78	54
RMNH 21036b	New Guinea	41	73	116	81	110	80	74	58
RMNH 21036e	New Guinea	41	75	114	80	112	78	76	60
ZMA 10201	New Guinea	42	81	131	88	125	92	78	69

Appendix 1 (continued)**Naturalis Museum specimens and scalation data included in the PCA.**

Catalog number	Island	P	Q	XY	m	S	T	N	R
ZMA 10208	New Guinea	43	72	125	73	114	90	73	65
RMNH 21037	New Guinea	42	75	128	80	128	92	76	58
RMNH 21038	New Guinea	41	68	118	80	118	87	72	60
RMNH 21034	New Guinea	44	82	128	85	123	85	77	66
RMNH 21046	New Guinea	44	70	129	84	120	87	72	53
RMNH 5359	New Guinea	41	80	115	80	113	88	72	67
RMNH 21018	New Guinea	41	77	115	78	112	84	71	62
RMNH 21050	New Guinea	41	75	118	87	116	79	72	62
RMNH 6726	New Guinea	43	73	121	82	122	80	85	59
RMNH 21040	New Guinea	40	76	128	81	122	87	78	59
RMNH 21020	New Guinea	40	78	123	84	125	83	74	65
ZMA 10194b	New Guinea	48	85	143	89	136	91	83	68
ZMA 10194c	New Guinea	42	77	124	81	122	95	77	68
ZMA 10200	New Guinea	42	66	121	73	115	74	75	46
RMNH 21035	New Guinea	42	73	119	78	111	81	73	52
RMNH 5260	New Guinea	36	60	116	74	110	82	73	51
RMNH 21048	New Guinea	45	74	113	80	115	84	67	56
RMNH 3151	Ravak	40	76	139	82	115	82	80	58
RMNH 3189	Seram	53	91	152	100	150	96	91	60
RMNH 3190a	Ternate	43	78	136	88	120	93	92	57
RMNH 3190b	Ternate	44	81	133	94	128	90	86	59
ZMA 15417	Ternate	43	76	140	85	127	94	87	58
ZMA 11146c	Unknown	43	72	140	80	123	87	76	59
ZMA 11146d	Unknown	42	70	131	79	121	84	73	61
ZMA 10192a	Waigeo	47	77	146	90	122	91	87	62
ZMA 10192b	Waigeo	48	82	151	82	123	91	80	64
ZMA 10192c	Waigeo	42	71	138	85	120	86	82	56
ZMA 10192d	Waigeo	48	73	147	78	119	86	84	61
ZMA 10192f	Waigeo	42	77	139	85	117	86	83	53
ZMA 10192g	Waigeo	42	77	141	79	125	86	80	54
ZMA 10192h	Waigeo	47	80	140	85	123	81	83	54



A dark morph of a male Fowler's Toad (*Anaxyrus fowleri*) in a cranberry (*Vaccinium macrocarpon*) bog. The toad was vocalizing just before this picture was taken. The uninflated and darkly pigmented vocal sac is partially visible. *Photo by Brad Timm.*



Fowler's Toad (*Anaxyrus fowleri*) occupancy in the southern mid-Atlantic, USA

¹Kara S. Jones and ^{2,3}Todd A. Tupper

¹Department of Environmental Science and Policy George Mason University, Fairfax, Virginia 22030, USA ²Department of Science, Technology and Business Northern Virginia Community College Alexandria, Virginia 22311, USA

Abstract.—We assessed the effects of landscape structure on *Anaxyrus fowleri* (Fowler's Toad) site occupancy using 14 years of call survey data collected from 250 sites in Virginia and Maryland, and landscape variables derived from the National Wetlands Inventory, U.S. Census Bureau, National Land Cover Databases, and U.S. Department of Agriculture. We also conducted a time series analysis on *A. fowleri* occupancy rates using call survey data collected throughout Virginia and Maryland. We found *A. fowleri* site occupancy to be negatively affected by deciduous forest, hay crops, development and agricultural pesticides, and we identified a negative interannual trend in occupancy rates between 1999 and 2012.

Key words. Fowler's toad, amphibian declines, calling anuran surveys, North American Amphibian Monitoring Program, landscape ecology, species-habitat modeling, anurans

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Introduction

Amphibian populations are declining globally, with anthropogenic degradation of landscapes near wetlands having a major impact on many species of pond-breeding amphibians (Findlay and Houlahan 1997; Blaustein and Kiesecker 2002). Upland habitats surrounding wetlands are vital for successful dispersal, foraging, and non-breeding activities, making upland habitat quality critical to the life history of pond-breeding amphibians (Windmiller 1996; Semlitsch 2000; Gibbons 2003; Bartlet et al. 2004). The negative effects of landscape degradation on many amphibian species, including hydroperiod alteration, pollution of wetlands from roadway runoff and agricultural chemicals, and mechanical disturbance of foraging, retreat and burrowing sites (Luo et al. 1999; Turtle 2001; Gray et al. 2004b) are fairly well understood. These anthropogenic disturbances can ultimately impact mobility and survival of larval, juvenile, and adult amphibians, and can lead to population declines and extirpations (Blaustein and Kiesecker 2002; Gray et al. 2004a). Thus, understanding how natural and anthropo-

genic landscape-level processes effect amphibian populations is critical to amphibian conservation.

The Fowler's Toad, *Anaxyrus (Bufo) fowleri*, is widely but irregularly distributed throughout the eastern United States, occurring from southern New England to the Florida Panhandle and as far west as Missouri, Arkansas, and Louisiana (Netting and Goin 1945; Green 1992; Klemens 1993; Conant and Collins 1998). Though typically associated with coastal dune systems and scrub-pine forests, *A. fowleri* also occurs in rocky and sparsely vegetated areas in dry, sandy, deciduous woodlands, and in agricultural and developed areas (Schlaugh 1976, 1978; Klemens 1993; Zampella and Bunnell 2000; Rubbo and Kiesecker 2005; Gooch et al. 2006). Some biologists and naturalists have thus described *A. fowleri* as being tolerant of urbanization, and scarification in agricultural areas (Ferguson 1960; Martof et al. 1980; Klemens 1993; Rubbo and Kiesecker 2005; Gooch et al. 2006). However, other studies suggest that *A. fowleri* are habitat specialists sensitive to environmental perturbations (Breden 1988; Green 2005; Tupper and Cook 2008).

Correspondence. Email: ³ttupper@nvcc.edu

In Canada, *A. fowleri* are federally protected (Oldham 2003), but they are not considered a species of concern in the United States. *Anaxyrus fowleri* populations are believed to be relatively stable and abundant in the eastern United States (Conant and Collins 1998). However, *A. fowleri* extirpations have been documented in the northeastern and southeastern United States (Breden 1988; Klemens 1993; Mierzwa et al. 1998; Tupper and Cook 2008; Walls et al., 2011; Milko 2012). These extirpations were largely attributed to anthropogenic disturbances, such as habitat degradation, pesticide application, road mortality (National Park Service, unpubl. data), hydroperiod alteration, competition from invasive species, and probable increased predation pressures from urban tolerant predators such as skunks (*Mephitis mephitis*) and raccoons (*Procyon lotor*) (Schaff and Garton 1970; Lazell 1976; Groves 1980; Klemens 1993; Tupper and Cook 2008; Milko 2012).

In the southern mid-Atlantic region, *A. fowleri* occur throughout Virginia and Maryland, but are less common outside of the Coastal Plain (Mitchell and Reay 1999). Coastal regions are thought to contain more favorable upland habitats for this species (see Martof et al. 1980; Mitchell and Reay 1999; Cook et al. In prep), but much of the Coastal Plain in Virginia and Maryland is more densely populated and intensely developed than western regions. For instance, the mid-Atlantic Coastal Plain has the highest population density and second-highest growth rate of all ecoregions in Virginia (VGDIF 2005). If *A. fowleri* are sensitive to landscape perturbations, human population growth and development may lead to *A. fowleri* population declines in the southern mid-Atlantic.

To the best of our knowledge, quantitative data describing the effects of landscape-level variables on *A. fowleri* are non-existent for the mid-Atlantic and are limited elsewhere (see Gooch et al. 2006; Tupper and Cook 2008; Birx-Raybuck 2010; Eskew et al. 2011). Occupancy trend analyses of *A. fowleri* populations indicate that

they are stable in most mid-Atlantic states (except Maryland; see Weir et al. 2014), but these analyses are temporally limited (Weir et al. 2009). Thus, critical thresholds in landscape-level variables essential to *A. fowleri* occupancy are unknown and it is unclear if southern mid-Atlantic populations are stable over the long term. Therefore our objectives were to identify and describe landscape-level variables that influence *A. fowleri* site occupancy and to complete a more comprehensive time-series analysis for this species in the southern mid-Atlantic.

Materials and Methods

Site selection and data collection

We randomly selected 250 sites in Virginia and Maryland for landscape-level analyses (Fig. 1). Selected sites were North American Amphibian Monitoring Program (NAAMP) calling anuran survey points (adjacent to wetlands) that were surveyed with anuran call counts between 1999 and 2012 (Weir and Mossman 2005). Movement data for *A. fowleri* are limited, but available studies indicate that a 1 km buffer surrounding breeding wetlands is a biologically meaningful distance for analyzing the effects of landscape features on anuran (including *Anaxyrus* spp.) occurrence (Clarke 1974; Miaud et al. 2000; Muths 2003; Bartlet et al. 2004; Smith and Green 2005; Forester et al. 2006). Therefore, our landscape variables were derived from 1 km buffers surrounding calling survey points. Any calling survey points found to have overlapping buffers were removed from analysis. Anuran call data (ranked ordinal values based on chorus intensity [0–3]) and sampling covariates (ambient temperatures, sky and wind conditions, and noise disturbance levels) were collected in accordance with NAAMP guidelines by trained NAAMP volunteers (Weir and Mossman, 2005).

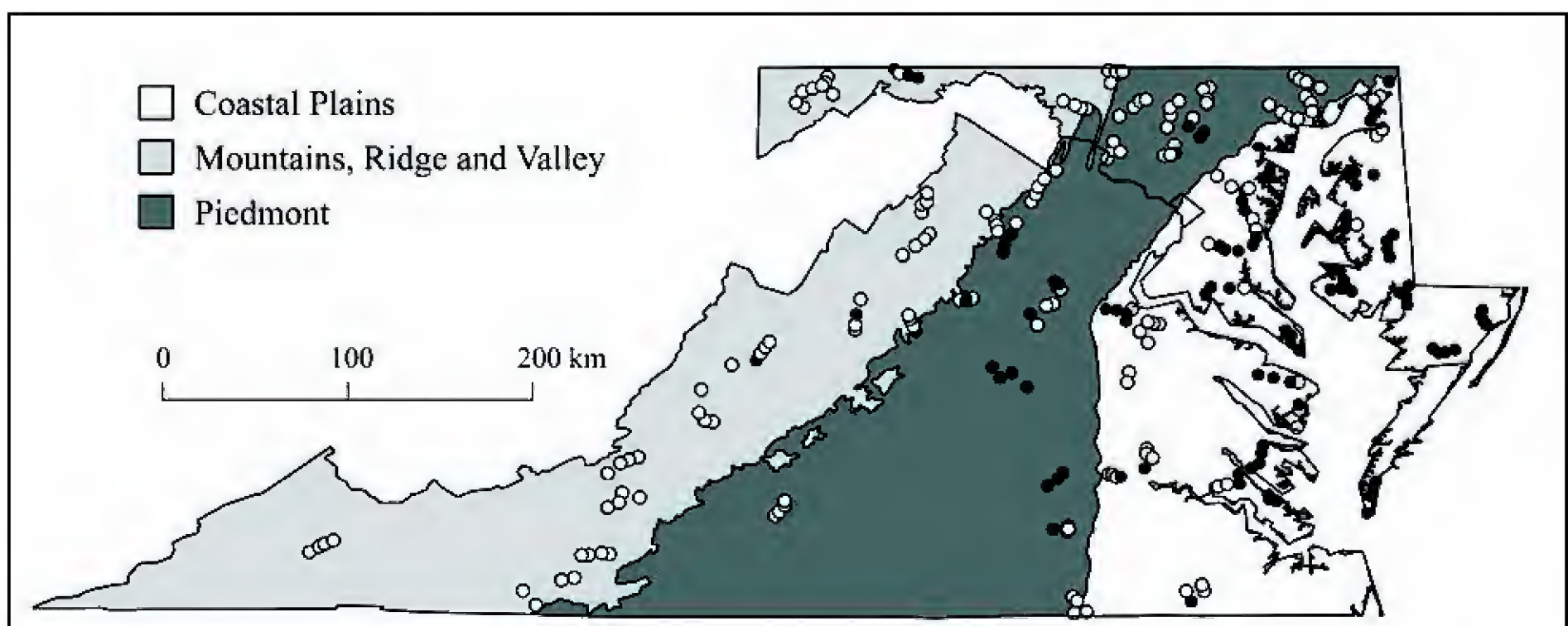


Fig. 1. Map of calling anuran surveys conducted in Maryland and Virginia. Closed circles indicate sites occupied by *A. fowleri* and open circles indicate unoccupied sites.

Calculation of landscape variables

We quantified landscape variables using data from four publicly available sources: (1) the National Wetlands Inventory (NWI) from the U.S. Fish and Wildlife Service; (2) 2012 TIGER/Line road data from the U.S. Census Bureau; (3) the National Land Cover Database (NLCD2006) from the Multi-Resolution Land Characteristics Consortium; and (4) the National Pesticide Use Database from the U.S. Department of Agriculture. Initial data manipulation was done in QuantumGIS (QGIS; QGIS Development Team 2011). For NWI data, we extracted distance from calling survey sites to nearest wetland and determined the number and types of wetlands within a 1 km buffer zone of calling survey sites. Using TIGER/Line road files, we calculated road length and type within 1 km buffers. We prepared land cover data by clipping NLCD2006 data for each buffer into an individual raster file. These files were then imported into R (R Core Team 2013) and analyzed using the SDMTTools package (VanDerWal 2013). Total pesticide application rate (kg/km²) at each site was determined by calculating the sum of application levels within each buffer for all pesticides listed in the National Pesticide Use Database.

Data Analyses

We used the R package Unmarked (Fiske and Chandler 2011) to identify landscape-level variables associated with *A. fowleri* occupancy. Landscape level habitat data were only available for a single year, so we used MacK-

enzie et al.’s (2002) occupancy model to account for imperfect detectability, particularly false-negative detections, when evaluating habitat variables. False-positive detections can also result in high site occupancy biases, but false-positive detection rates vary between species, and previous tests of NAAMP volunteers resulted in no false-positive detections of *A. fowleri*, even amongst inexperienced volunteers (Genet and Sargent 2003; Royle and Link 2006; McClintock et al. 2010). Therefore, false-positive detections of *A. fowleri* were unlikely to be at levels high enough to bias site occupancy and were not considered in the modeling process.

We assessed models using a multimodel inference approach (see Burnham et al. 2011). We used 19 non-correlated site covariates (Table 1) considered to be biologically meaningful in anuran breeding site selection when creating a priori models (Cushman 2006). Julian date (date) and temperature (temp) were found to affect detection probability; therefore these two sampling covariates were used in all models. We ranked competing models with Akaike Information Criterion (for data sets with high independent to dependent variable ratio [AICc]) by calculating differences between candidate models and the lowest AICc (Δ_i AICc) model. We used Akaike weight (w_i) for each model to guide selection.

To determine change in occupancy between years, we fit a colonization-extinction model (MacKenzie et al. 2003) using date and temp as covariates to account for differences in repeated sampling periods. We then used a smoothed trajectory to determine mean occupancy for each year (Weir et al. 2009). Serial autocorrelation in

Table 1. Landscape variables used in analyses of *A. fowleri* calling anuran survey data for in Virginia and Maryland.

Variable	Description
Crops	Proportion of area used for annual crops or perennial woody crops
Dec	Proportion of forest with >75% canopy cover of deciduous trees
Dev	Proportion of area that has been developed, including suburban and urban areas
Ever	Proportion of forest with >75% or more evergreen trees
For	Proportion of all forest habitats (Dec + Ever + Mix)
Grass	Proportion of area with graminoids or herbaceous vegetation covering over 80% of land which might be grazed but not tilled
H	Habitat Diversity, calculated as Shannon’s diversity index using habitat proportions
Hay	Proportion of area planted with grass/legume mixtures used for grazing or hay crops
Mix	Proportion of mixed forest with neither deciduous nor evergreen dominant
Patch	Number of terrestrial habitat patches divided by total number of possible habitat patches (i.e., if each raster square represented a different type of habitat)
Pesticides	Total kg/km ² of agricultural pesticides applied within 1 km radius of buffer from CSS
Road	Total length of all roads in a 1 km radius buffer from CSS
Shrub	Proportion of area with canopy less than 5 m tall (e.g., shrubs and early successional forest)
Wavg	Average size of wetlands in a 1 km radius buffer from CSS \pm in m ²
Wdis	Distance (m) of nearest wetland from Calling Survey Site (CSS)
Wet	Proportion of total buffer area covered by wetlands
Wnear	Size (ha) of the wetland nearest to the CSS
Wnum	Number of wetlands in a 1 km radius buffer from CSS
Wtype	Number of different types of wetlands in a 1 km radius buffer from CSS

the residuals violated assumptions of a parametric linear regression analysis; therefore we used a non-seasonal Autoregressive Integrated Moving Average (ARIMA) analysis to better understand changes in *A. fowleri* occupancy rates over time. We determined significance of parameters using a conditional least squares estimation. We assessed model fit with a Ljung-Box Q-test whereby a high *P*-value indicates that autocorrelation functions are not significantly different than white noise (Ljung and Box 1978).

We used an empirical Bayesian approach to determine conditional distribution of occurrence from the colonization-extinction model and then extrapolated best unbiased predictions of occupancy probability at each site. All sites with an occupancy probability ≥ 0.75 were considered occupied. To determine distributions of specific variables at occupied and unoccupied sites, we created site occupancy accumulation curves for each habitat variable. Habitat recommendations are based on maximum values found at 90% of occupied sites.

Trend analysis was completed in Minitab v.16 (Minitab Inc., Pennsylvania, USA) and all other analyses were completed in R v.3.0.2. Maps and figures were created using QGIS 2.0 and Excel 2010 (Microsoft Corp., Washington, USA).

Results

Landscape analyses

Two hundred fifty sites were sampled between 1999 and 2012 throughout Maryland and Virginia, 108 (42.8%) of which had at least one detection of *A. fowleri*. Approximately eight-percent (300/3841) of sampling events resulted in detections. Not all sites were sampled every year (ranging from 1–14 years, $\bar{x} = 6.22$; ± 0.197), but most sites were surveyed > 10 times ($\bar{x} = 23.1$; ± 1.09).

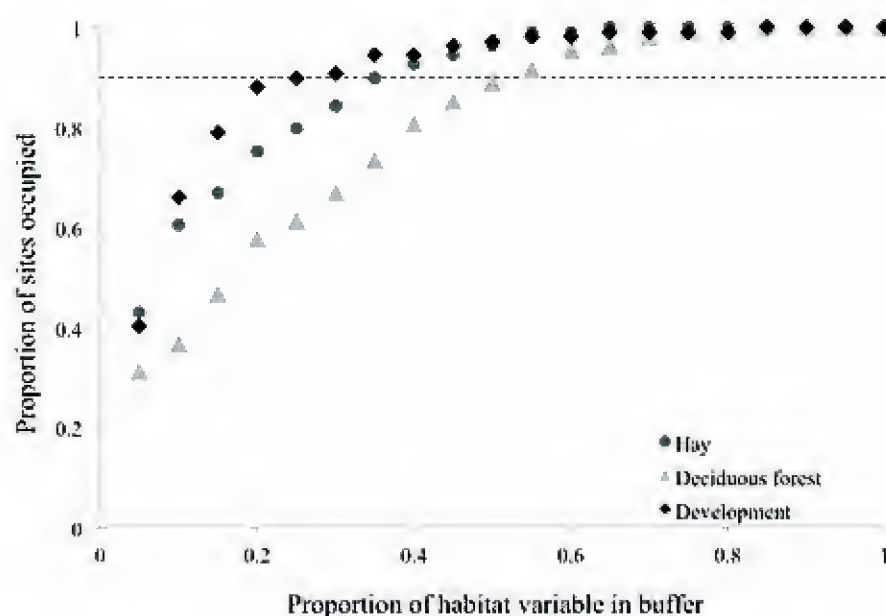


Fig. 2. Accumulation curve showing the maximum proportions of habitat variables found at each occupied site. Ninety-percent of occupied sites were covered by less than 0.25 development, 0.35 hay, and 0.50 deciduous forest cover.

Table 2. Top five models and full model from unmarked analysis of *A. fowleri* occupancy in Virginia and Maryland. Models are ranked from lowest to highest with AICc values. Julian date and temperature were used as sampling covariates in all models. The full model was constructed using the maximum number of site covariates which would create a model that converged: Wnum + Wavg + Road + Ever + Dec + Mix + Crops + Hay + Dev + Wet + Core + Patch + Pesticides.

Model	AICc	Δ_i AICc	w_i
Dec + Hay + Dev + Pesticides	1768.65	0	0.62
Dec + Hay + Dev	1769.55	0.91	0.38
Dec + Hay + Pesticides	1780.54	11.90	0.00
Dec + Dev + Pesticides	1791.16	22.52	0.00
Pesticides	1964.45	195.80	0.00
Full model	2958.68	1190.03	0.00

Table 3. Transformed and untransformed beta coefficients from top occupancy models.

Variable	Untransformed	Transformed	Estimated SE
(Intercept)	3.887	0.980	0.017
Dec	-6.148	0.002	0.002
Hay	-5.373	0.005	0.005
Dev	-4.814	0.008	0.009
Pesticides	-0.005	0.499	0.013

Bayesian analysis indicated that only two sites where no detections occurred had an occupancy probability ≥ 0.75 .

We found strong support for a model indicating that deciduous forest, hay, development and pesticides negatively influenced *A. fowleri* occupancy (AICc = 1768.65, $w_i = 0.62$; Tables 2 and 3). The buffers ranged from 0–97% deciduous forest ($\bar{x} = 0.32$; ± 0.015), 0–74% hay ($\bar{x} = 0.18$; ± 0.011), 0–83% development ($\bar{x} = 0.12$; ± 0.009), and 0–535 kg pesticides applied ($\bar{x} = 55.7$; ± 5.231). Ninety-percent of occupied sites were covered by less than 25% development, 35% hay, and 50% decidu-

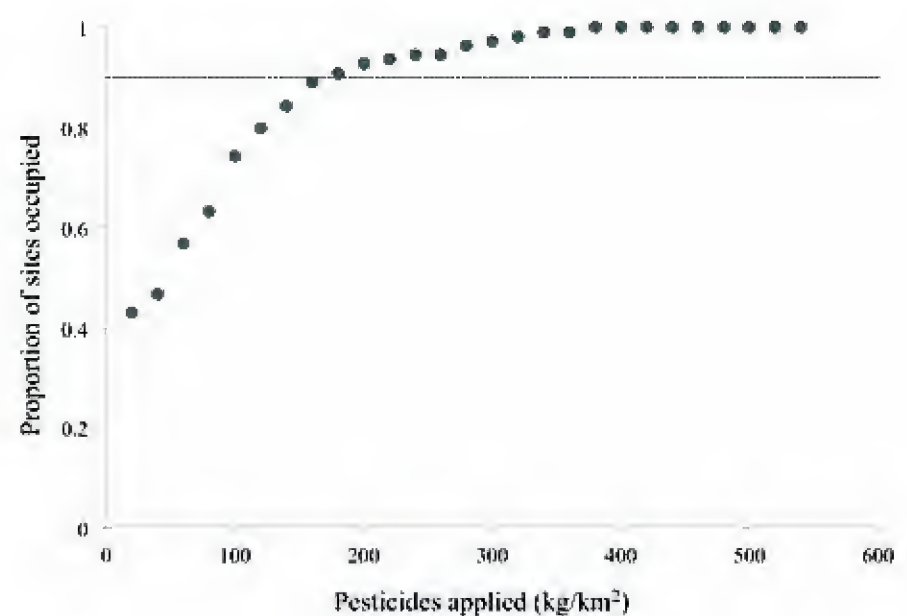


Fig. 3. Accumulation curve showing the maximum agricultural pesticide application rates at occupied sites. The maximum amount of pesticides applied at 90% of occupied sites was 165 kg/km².

ous forest (Fig. 2). The maximum amount of pesticides applied at 90% of occupied sites was 165 kg/km² (Fig. 3).

Time-series analyses

Using ARIMA analysis, we found that a single autoregressive term was contributing to interannual changes in *A. fowleri* occupancy rates ($t = 4.32$, $P < 0.001$). We confirmed that the model was valid, with uncorrelated residuals ($Q = 13.2$, $df = 9$, $P = 0.152$). Trend analysis indicated a downward trend in occupancy rates over time, with occupancy decreasing from 55.3% in 1999 to 29.5% in 2012 (Fig. 4).

Discussion

Forest cover

Many contemporary landscape-level studies indicate a positive relationship between amphibian species and forested habitat within buffers of varying sizes around breeding ponds (see Cushman 2006). We were able to distinguish between forest types on a fairly large scale and identified a negative relationship between *A. fowleri* occupancy and deciduous forest. Although both species can be sympatric, *A. fowleri* is largely replaced by American Toads (*Anaxyrus americanus*) in later successional forests that are dominated by moister, more nutrient rich soils, and hardwood trees (Wright and Wright 1967; Lazell 1976; Klemens 1993). Our results confirm long-

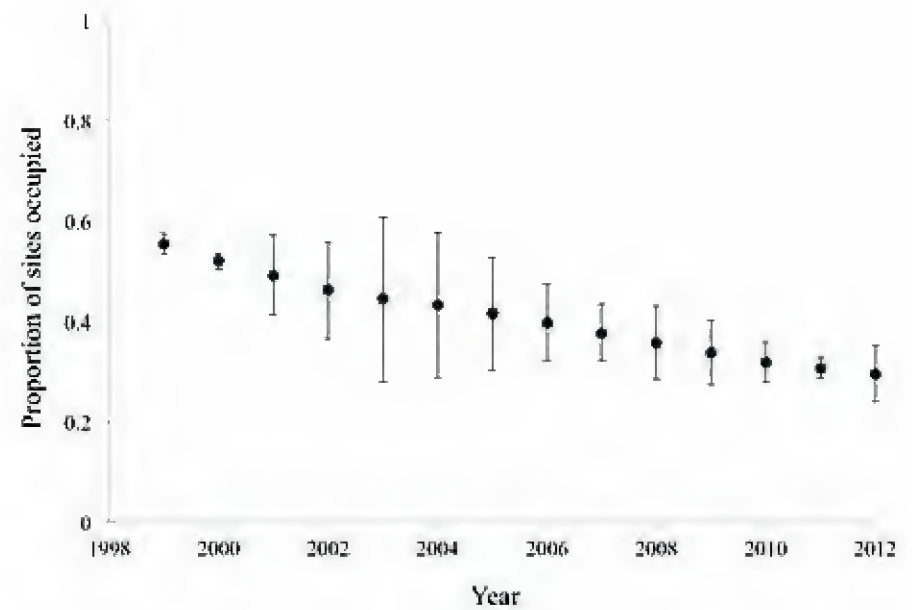


Fig. 4. Mean site occupancy and confidence intervals of *A. fowleri* in Virginia and Maryland from 1999–2012. Time series analysis indicates a 53% decrease in site occupancy, from 55.3% in 1999 to 29.5% in 2012.

standing observations made across *A. fowleri*'s range that suggest they are more common in early successional habitats that are either relatively open or dominated by mixed or coniferous forest (Hubbs 1918; Hoopes 1930; Netting and Goin 1945; Littleford 1946; Cory and Manion 1955; Wright and Wright 1967; Clarke 1974; Green 1989; Lazell 1976; Klemens 1993; Zampella and Bunnell 2000; Tupper and Cook 2008).

Hay

The proportion of area covered by grass/legume mixtures used for grazing or hay crops within the 1 km buffer was



The Provincelands of Cape Cod National Seashore, Barnstable County, Massachusetts, USA. The reddish vegetation in the center of the photo is a cranberry (*Vaccinium macrocarpon*) bog, a wetland used for breeding by the Fowler's toad. The surrounding landscape is ideal for the Fowler's toad and supports one of the largest populations of this species in the United States. The landscape contains a patchwork of sand, pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*), and dune grass (*Ammophila breviligulata*). Photo by Rebecca Flaherty.

found to have a significantly negative impact on *A. fowleri* occurrence. Agricultural development can negatively affect anuran dispersal abilities, and soil compaction associated with agricultural landscape alterations may prohibit anuran burrowing (Whalley et al. 1995; Jansen et al. 2001; Gray et al. 2004b). Wetlands within agricultural landscapes may be altered physically and biologically such that postmetamorphic anurans emerge smaller and presumably less fit (Beja and Alcazar 2003; Gray et al. 2004a,b).

Development

We found development to be another significant variable negatively affecting *A. fowleri* occurrence. Development contributes to reduced genetic diversity in pond breeding amphibians, increased pollution of upland and wetland habitats, increased road mortality, and microclimate alteration of remaining habitat patches (Soulé 1987; Reh and Seitz 1989; Fahrig 1995; deMayndier and Hunter 1998; deMaynadier and Hunter 2000; Turtle 2001; Timm and McGarigal 2014). Various studies indicate that development and fragmentation is detrimental to amphibian persistence (see review in Cushman 2006), including *A. fowleri* and congener *A. americanus* (Schlauch 1976, 1978; Gibbs et al. 2005; Walls et al. 2011). However, studies conducted throughout the United States (e.g. New Jersey [Zampella and Bunnell 2000], Pennsylvania [Rubbo and Kiesecker 2005], North Carolina [Gooch et al. 2006], and Louisiana [Milko 2012]) suggest that *A. fowleri* are urban tolerant. While these studies have shown that *A. fowleri* can occur in developed habitats, they do not include pre-development population sizes, are temporally and spatially limited, and are likely referring to suburbanization rather than large-scale urbanization (see Schlauch 1978).

Pesticides

While the differences in AICc values between the top two models were small, four out of the top five models included agricultural pesticide application levels as a negative covariate, indicating that pesticide exposure may play an important role in *A. fowleri* site occupancy. Data suggest that chemical pesticides associated with agriculture have wide-ranging direct effects on amphibians, including endocrine disruption, immunosuppression, developmental delays, and increased mortality (Mann et al. 2009). Exposure to insecticides was found to be highly toxic to larval *A. fowleri* in laboratory studies (see review in Green 2005) and had sub-lethal effects its congener, *A. americanus*, causing eye and limb deformities, increased time to metamorphosis, and reduced post-metamorphic body size (Harris et al. 2000; Boone and James 2003; Howe et al. 2004). Agricultural runoff containing pesticides may be contaminating certain wetlands in this

study, thus potentially accounting for reduced *A. fowleri* occupancy rates in agricultural landscapes.

Trends

By pooling data from Maryland and Virginia, we estimate that *A. fowleri* occupancy has decreased by approximately 53% over the last 14 years. Weir et al. (2009) found a significant, but negligible, negative occupancy trend for *A. fowleri* in Delaware, and indicated unchanging occupancy rates in Virginia, Maryland, West Virginia, and New Jersey between 2001 and 2007. However, a more recent study (conducted as the same time as ours, with a similar data set, see Weir et al. 2014) also indicated *A. fowleri* declines in Maryland. Differences in trend estimates between our study and Weir et al. (2009, 2014) may be due to differing sample sizes. Since we nearly doubled the scope of analysis of Weir et al. (2009) and have three more years than Weir et al. (2014), we believe our results more accurately describe trends in *A. fowleri* occupancy in Maryland and Virginia. Although a more comprehensive analysis is needed to identify the proximate causes of decline in *A. fowleri* in Maryland and Virginia, we suspect that its declines are in part due to the recent loss of subclimax communities. Virginia has lost 51.6% of its softwood forest since 1940 (VDOF 2014) and early successional habitats have been steadily juxtaposing to later successional seres throughout Maryland: As of 2008 less than 10% of existing Maryland forests were occupied by early successional regimes (Lister 2011).

Anaxyrus fowleri may be able to persist longer in moderately developed coastal environments (Schlauch 1978) than other pond-breeding amphibians due to their high fecundity rates, salt tolerance, desiccation resistance, and ability to breed in wetlands with varying hydroperiod regimes (Wright and Wright 1967; Claussen 1974; Markow 1997; Tupper and Cook 2008; Birx-Raybuck 2010; Eskew et al. 2012). The ability of *A. fowleri* to occupy these types of habitats is advantageous because they harbor fewer interspecific amphibian competitors (see Martof et al. 1980; Klemens 1993; Mitchell and Reay 1999). If early successional habitats continue to become less widespread in the mid-Atlantic, coastal regions may become more important to the long-term persistence of *A. fowleri*. However, much of the southern mid-Atlantic coastal plain is densely populated (VGDIF 2005) and intensely developed. Thus, successional changes occurring further inland coupled with increased urbanization of the southern mid-Atlantic coastal plain could potentially exacerbate declines.

Conclusions

Amphibian populations are more vulnerable to habitat loss and fragmentation when located on the margins of

their geographic range (Swihart et al. 2003). Our data indicate that even in the middle of their range, *A. fowleri* occupancy rates are declining. Landscapes most appropriate for this species appear to contain only moderate amounts of deciduous forest ($\leq 50\%$), few hay crops ($\leq 35\%$), relatively little development ($\leq 25\%$), and low pesticide application rates.

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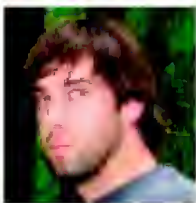
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Kara Jones is a naturalist and graduate student in the Department of Environmental Science and Policy at George Mason University. Her area of specialization is in worm snake ecology and species-habitat modeling. *Photographed by Kara Jones.*



Todd Tupper is an associate professor of biology at Northern Virginia Community College. He teaches biology, zoology, and biostatistics. His area of interest is amphibian monitoring and conservation. *Photographed by Natasha Abner.*



Two new species of the genus *Cylindrophis* Wagler, 1828 (Squamata: Cylindrophiidae) from Southeast Asia

^{1,6}A.A. Thasun Amarasinghe, ²Patrick D. Campbell, ³Jakob Hallermann,
⁴Irvan Sidik, ¹Jatna Supriatna, and ⁵Ivan Ineich

¹Research Center for Climate Change, University of Indonesia, Gd. PAU Lt. 8.5, Kampus UI, Depok 16424, INDONESIA ²Department of Life Sciences, Darwin Centre, Natural History Museum, Cromwell Road, South Kensington, London SW7 5BD, ENGLAND ³Zoologisches Museum Hamburg, Universität Hamburg, Martin-Luther-King-Platz 3, 20146 Hamburg, GERMANY ⁴Museum Zoologicum Bogoriense, The Indonesian Institute of Science (LIPI), Widyasatwaloka Building, Jl. Raya Jakarta Bogor, Cibinong 16911, INDONESIA ⁵Muséum national d'Histoire naturelle, Sorbonne Universités, ISYEB (Institut de Systématique, Évolution et Biodiversité), UMR 7205 (CNRS, MNHN, UPMC, EPHE), 57 rue Cuvier, CP 30 (Reptiles), 75005 Paris, FRANCE

Abstract.—The original description of *Anguis ruffa* (now *Cylindrophis ruffus*) given by Laurenti in 1768 is not sufficiently comprehensive for the morphological identification of the species, and the type locality, given as “Surinami,” is in error. However, Schlegel in 1844 corrected the type locality as “Java in Indonesia.” There is also, currently, no proof of the existence of a type specimen of *Anguis ruffa*. Therefore, we accept Schlegel’s correction of the type locality being Java. *Anguis ruffa* is here redescribed based on museum specimens collected from Java only. Because the original description of *C. r. burmanus* is insufficiently comprehensive we here redescribe this species using the presumed type series collected from Myanmar, and we also designate a lectotype. We examined a large number of *Cylindrophis* specimens deposited in European and Indonesian museums, using morphological and meristic characters, plus coloration. We identified four groups based on the number of scale rows around the midbody (17, 19, 21, and 23). Among the *Cylindrophis* collections at Natural History Museum, London and Muséum national d’Histoire naturelle, Paris, we have discovered several specimens which do not fit any recognized species descriptions. We here describe two new species chosen from among them: *C. jodiae* sp. nov. from Vietnam and *C. mirzae* sp. nov. from Singapore. Finally, we provide color plates showing the different body colorations for all the recognized species in the genus *Cylindrophis*.

Key words. Biogeography, Indonesia, pipe snake, Singapore, taxonomy, Vietnam

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Introduction

The first species of pipe snake was described by Linnaeus (1758) as *Anguis maculata* from Sri Lanka (America in error *vide* Deraniyagala 1955), followed by *Anguis ruffa* described by Laurenti (1768). The genus *Cylindrophis* was established by Wagler (1828) with a type species from Java, *Cylindrophis resplendens* Wagler 1828, a binomen later synonymized with *Cylindrophis ruffus* by Schlegel (1844). After Wagler (1828), several additional species (e.g., *Cylindrophis melanotus* Wagler 1830, *Cylindrophis lineatus* Blanford 1881, *Cylindrophis isolepis*

Boulenger 1896, *Cylindrophis opisthorhodus* Boulenger 1897, *Cylindrophis boulengeri* Roux 1911, *Cylindrophis aruensis* Boulenger 1920, *Cylindrophis celebensis* Smith 1927, *Cylindrophis heinrichi* Ahl 1933, *Cylindrophis engkariensis* Stuebing 1994, *Cylindrophis yamdena* Smith and Sidik 1998) and one subspecies, *Cylindrophis rufus burmanus*, Smith 1943) were added to the genus. Most of the taxa are endemic to one island or small island group. The Asian genus *Cylindrophis* was formerly included in the family Uropeltidae, later McDowell (1975) included the genus in the family Cylindrophiidae, along with the genus *Anomochilus* Berg 1901. Furthermore,

Correspondence. Email: ⁶thasun@rccc.ui.ac.id

McDowell (1975) synonymized *C. celebensis* and *C. heinrichi* with the Sulawesi endemic *C. melanotus*. Recently, Wallach et al. (2014) synonymized the trinomen, *C. r. burmanus* with *C. ruffus*. Therefore, the genus presently consists of ten valid monotypic species (Wallach et al. 2014) of which nine are distributed in Southeast Asia (Stuebing 1994), and one (*C. maculatus*) is endemic to Sri Lanka (Somaweera 2006). There are no *Cylindrophis* in the Indian peninsular (Smith 1943). Later, Cundall et al. (1993) allocated the genus *Anomochilus* to its own family, Anomochilidae, thus rendering the family Cylindrophidae monotypic. The family Cylindrophidae can be distinguished from its sister family Anomochilidae by having a mental groove, nasals in contact, and no preocular (Das et al. 2008).

The original description of *Anguis ruffa* is limited to only a few words: “Corpore aequali, ruffo, lineis transversalibus albis interruptis; abdomine vario,” and the type locality was given as “Surinami,” in error. An English translation of the original description was given by Adler et al. (1992) as “Body uniform, red, broken white transverse bands; abdomen various. Lives in Surinam; housed in Gronovius’s Museum.” The holotype was deposited first at “Museo Gronoviano” / Museo Laurentii Theodori Gronovii [may be Museum Gronovianum], Lugdunum Batavorum (= Leiden) and later believed to have been transferred to the Naturalis Biodiversity Center, Nationaal Natuurhistorische Museum (Rijksmuseum), Leiden, Netherlands (RMNH.RENA). Even though Iskandar and Colijn (2002) regarded the type materials of *Anguis ruffa* as lost from Naturalis Biodiversity Center, there is no evidence to support that the type was ever deposited there in the first place. Wagler’s (1828) species *Cylindrophis resplendens*, which was described from Java, was synonymized with *Cylindrophis ruffus* by Schlegel (1844). The type locality of *Anguis ruffa* was later corrected from Suriname to Java in Indonesia (*fide* Schlegel 1844). Although Gray (1849) considered that the Javanese population is a variation (*javanica*) of *Anguis ruffa*, subsequent authors have accepted that the type locality is indeed Java (e.g., Smith 1943, Taylor 1965). Furthermore, Taylor (1965) invalidated [*id est nomen oblitum*] Laurenti’s (1768) name and choose the next available name, *Tortrix rufa* Schlegel 1844 [*id est nomen protectum*].

Although the species name was usually spelled erroneously as “*rufus*” in older publications, a justification is given for this by Adler et al. (1992) as the original spelling given by Laurenti (1768) is “*ruffa*.” Smith (1943) described a subspecies, *Cylindrophis rufus burmanus*, from Burma (now Myanmar). In the original description of *C. r. burmanus*, he failed to mention how many specimens he examined, but it is clear from the description that he had several specimens at his disposal at the time. According to Smith (1943), ventrals varied from 201–225, and subcaudals from 5–7, but he only provided the measurements for the largest specimen as “Total length: 330, tail 10 mm” [i.e., SVL 320 mm]. The dis-

tribution was given as “Range. Tenasserim and Burma as far North as Myitkyina” but a precise type locality was not given. Furthermore, Smith (1943) extended the distribution of “*Cylindrophis rufus rufus*” (*forma typica*) from Java to Siam (now Thailand), French Indo-China, Malay Peninsula and Archipelago. Although subsequent authors (e.g., Taylor 1965, Iskandar and Colijn 2002) have accepted the above trinomen from Myanmar, recently Wallach et al. (2014) included the subspecies under *Cylindrophis ruffus* because subspecies are not recognized in their catalogue. To date *Cylindrophis ruffus* has been widely recorded from Thailand, Laos, Vietnam, Myanmar, Cambodia, China, Malaysia, Singapore, and several Indonesian islands including Sumatra, Borneo, Java, and Sulawesi (Gray 1849; Boulenger 1888, 1893; Smith 1943; Deuve 1970; Dowling and Jenner 1988; Adler et al. 1992; Geissler et al. 2011; de Lang 2011, 2013). Several of these authors refer to undescribed species and it has also already been argued that *C. ruffus* being a complex of several species, is in need of a critical examination (Stuebing 1994; Smith and Sidik 1998). Our results below will be a preliminary step to the recognition of several unidentified species within this complex. An additional number of undescribed species are included in our examined material but pending larger samples, we prefer not to describe them at this time.

Materials and Methods

We have examined more than 150 *Cylindrophis* specimens deposited in various museum collections (Appendix 1): Museum Zoologicum Bogoriense, Bogor, Indonesia (MZB); Natural History Museum [formerly British Museum (Natural History)], London, United Kingdom (UK) (BMNH); Muséum national d’Histoire naturelle, Paris, France (MNHN-RA); Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt, Germany (SMF); Western Australian Museum, Perth, Western Australia, Australia (WAM); and Museum für Naturkunde, Berlin, Germany (ZMB). We compared all our examined specimens with past descriptions and other published data of all known congeners (Appendix 1). Museum acronyms follow Sabaj Pérez (2014).

We obtained distribution data from examined specimens, published literature as well as personal observations. The following characters were measured with a Mitutoyo digitmatic caliper to the nearest 0.1 mm and only along the left side of the body for symmetrical characters: snout–vent length (SVL), measured from tip of snout to anterior margin of vent; tail length (TL), measured from anterior margin of vent to tail tip. We counted supralabial and infralabial scales from the gape to the rostral and mental scales, respectively. We counted mid-body dorsal scale rows around the body, in three positions, on the neck (at the point of the 10th scale starting from the first scale after the mental groove on the ventral

side), midbody (at the point of half of the ventral count), and at one scale anterior to precloacal, always excluding the ventral scale from counts. When counting the number of ventral scales, we scored specimens according to the method described by Dowling (1951), but started from the first scale after the mental groove. We counted subcaudal scales from the first postcloacal scale to the scale before the tip of the tail.

All color descriptions and other associated color characters are based on preserved specimens. The presence and absence of white bands on the nape and the back, plus the shape of the band on the nape (narrow, when the band is wider than one scale-width; or wide, when the band is wider than one scale-width), the shape of the bands at back (complete, when the band is a complete dorsal ring; or interrupted, when the bands do not meet mid-dorsally), and the arrangements of the bands at back (constant, when the bands are regularly arranged and each part of the band arranged confronting each other; or alternating, when the bands are irregularly arranged and each part of the band arranged avoiding each other) are considered as morphological characters. We have not recorded the sex of the specimens other than where the hemipenis was everted because most of the examined specimens are old, having huge historical value, we decided to keeping them intact.

The distribution of each species (in Fig. 8) does not show precise localities (due to the general lack of precise localities in historical collections). Therefore, the whole biogeographical area or country is shaded for each species.

Results

The original description of *Anguis ruffa* given by Laurenti (1768) is not comprehensive enough for a morpho-

logical identification of the species. Our recent attempt to locate the type material of *C. ruffus* at RMNH was unsuccessful (Marinus Hoogmoed pers. comm. to Ivan Ineich on 23 October 2014). We believe that there are several species masquerading today within the currently accepted name *Cylindrophis ruffus*. We also believe that the type of *C. ruffus* first arrived in the Netherlands from Jakarta, Indonesia because of the following: (1) the Dutch East Indies (now Indonesia) was a Dutch colony under the administration of the Dutch Government since the early 17th century; (2) most of the specimens arriving at the Netherlands natural history collections prior to 1850 originated from Java, Indonesia, especially West Java which was where the administration capital was based, Batavia (now Jakarta); (3) there was a town called “Batavia” in the former Dutch colony of Suriname which could be misidentified with Batavia in Indonesia. Therefore, we accept Schlegel’s (1844) correction for the type locality of *Anguis ruffa* as Java. Furthermore, our attempt to locate the type material of *Cylindrophis resplendens* Wagler, 1828 (type locality: Java) which was believed to be deposited at MNHN-RA was again unsuccessful.

Our species examination and comparison also shows that *Cylindrophis ruffus burmanus* has morphological and meristic character differences large enough to elevate it to species level. Although Iskandar and Colijn (2002) raised it previously to the species level, they gave no justification for this. There are six specimens (see Table 1) collected from Burma in the BMNH today, among them two specimens (BMNH 1940.3.3.1–2) are labelled “*Cylindrophis ruffus burmensis*” and all the others as “*Cylindrophis rufus*.” As these specimens were probably present at the time of Smith when his manuscript was completed in 1938 [*fide* the preface of Smith (1943)] but delayed because of the second world war, they may be considered syntypes of *C. r. burmanus*. Although, there

Table 1. Details of the possible syntype series of *Cylindrophis ruffus burmanus* Smith, 1943 compared to the data provided in the original description; “—” = not applicable, “?” = not given, “*” = damaged.

Character	Smith (1943)	Catalogue Number (BMNH)					
		1940.3.3.1	1940.3.3.2	1891.11.26.28	1908.6.23.3	1925.12.22.4	1925.4.2.2
Species name on the label	—	“ <i>Cylindrophis ruffus burmensis</i> ”		“ <i>Cylindrophis rufus</i> ”			
Location	Tenasserim and Burma as far North as Myitkyina	Rangoon, Burma	Rangoon, Burma	Pyinmana, Upper Burma	Burma	Sahmaw, Myitkyina District, Burma	Thandoun, Burma
Presenter (collector unknown)	?	F.J. Meggitt		E.W. Oates	F. Wall		
Total length in mm	330	330	217.2	286	299.5	264	288
SVL in mm	[320]	320	212	280	293	256	280
Tail length in mm	10	10	5.2	6	6.5	8	8
Ventrals	201–225	213	213	209	221	~225*	201
Subcaudals	5–7	~6–7*	6	5	6	~6–7*	~5*

Table 2. Comparison of some morphometric, meristic, and morphological characters of *Cylindrophis* species which have 23, 19, and 17 midbody scale rows, based on examined materials; “—” = Not applicable.

Character	23 scale rows at midbody		19 scale rows at midbody				17 scale rows at midbody
	<i>C. aruensis</i> (n = 3)	<i>C. opisthorhodus</i> (n = 5)	<i>C. boulengeri</i> (n = 3)	<i>C. burmanus</i> (n = 6)	<i>C. melanotus</i> (n = 14)	<i>C. ruffus</i> (n = 14)	<i>C. engkariensis</i> (n = 1)
Location	Dammar	Flores	Wetar	Myanmar	Sulawesi	Java	Borneo
SVL (in mm)	155–305	270–470	240–310	212–320	292–575	257–715	473
Scale rows around neck	25–26	21–23	19–21	17–19	17–19	20–23	17
Scale rows around midbody	23	23	19	19	19	19	17
Scale rows around precloacal	18–20	18–21	17	16 or 17	17	17 or 18	17
Midventral scales	173–182	185–210	193–200	201–225	233–275	186–197	234
Subcaudals	6–7	6–7	5–6	5–7	6–8	5–8	5+1
Frontal > prefrontal (1) or < (0)	0	0	1	0	0	0	0
Pale band/ring on the nape present (1) or absent (0)	1	0	0	1	1	1	0
Pale band/ring wide (1) or narrow (0)	1	—	—	0	1	1	—
Pale band/ring complete (1) or dorsally interrupted (0)	0	—	—	0	0	0	—
Crossbands on the back present (1) or absent (0)	1	0	0	1	0	1	0
Crossbands complete (1) or interrupted (0)	0	—	—	0	—	0	—
Crossbands constant (1) or alternating (0)	0	—	—	0	—	1	—
Crossbands wide (1) or narrow (0)	0	—	—	0	—	1	—

is no indication of a holotype designation in the description, the specimen BMNH 1940.3.3.1 is exactly matching with the morphometric, meristic, and morphological characters given in the original description. We note also that the original description of *C. r. burmanus* was not comprehensive enough for identification. Therefore, we here designate the closely matching specimen (BMNH 1940.3.3.1), for which measurements were given in the original description, as the lectotype of *Cylindrophis ruffus burmanus* in order to stabilize the name with a recognized type specimen. Furthermore, we provide a comprehensive redescription on the basis of that lectotype, and its five paralectotypes located at the BMNH.

Among our examined sample at the BMNH and MNHN-RA, we found several specimens representing two morphospecies that do not fit the diagnoses of any known species. These specimens are morphologically distinct, geographically isolated, and well outside of the corrected distribution range of *C. ruffus*. The differences of those two morphospecies are large enough to consider them as “undescribed species.” Therefore, we formally describe them as new species in this paper. They differ from all other known species of the genus *Cylindrophis* (see Tables 2–3; Figs. 1–16) with respect to their coloration and body scalation, especially their midbody dorsal scale counts and ventrals. We assign the two new

species to the genus *Cylindrophis* based on the following character combination: a medium-sized snake with a cylindrical body, of nearly equal diameter throughout its length; a small head, not really distinct from the thick neck; a depressed snout; small eyes, with rounded pupils; the nostril pierced in the middle of a single nasal shield, slightly directed forwards; the upper head scales large and symmetrical; no internasals, loreals, or preoculars; a mental groove present; 21 rows of smooth and iridescent dorsal scales; the ventral scales barely enlarged, and the tail very short and blunt.

Furthermore, based on the number of scale rows around the midbody we have identified four morphological groups within the *Cylindrophis* genus. Note however that the phylogenetic validity of those groups has not yet been tested:

- (1) 17 midbody scale rows (one species): *C. engkariensis*—see Table 2.
- (2) 19 midbody scale rows (five species): *C. ruffus*, *C. melanotus*, *C. boulengeri*, *C. burmanus*—see Table 2.
- (3) 21 midbody scale rows (seven species): *C. maculatus*, *C. lineatus*, *C. isolepis*, *C. yamdena*, *C. jodiae* sp. nov. (see below), *C. mirzae* sp. nov. (see below)—see Table 3.
- (4) 23 midbody scale rows (two species): *C. opisthorhodus*, *C. aruensis*—see Table 2.

Systematics: We redescribe *Cylindrophis ruffus* and *C. burmanus* and describe two new species from Vietnam and Singapore, respectively, as follows:

***Cylindrophis ruffus* (Laurenti 1768)**

Anguis ruffa Laurenti 1768: 71.
(Figs. 1, 8; Table 2)

Synonyms:

Cylindrophis resplendens Wagler 1828: pl. 5, fig. 1. Type locality, Java.
Cylindrophis rufa javanica Gray 1849: 112. Type locality, Java.

Proposed standard English name: **Red-Tailed Pipe-Snake**

Proposed standard Indonesian name: **Ular Pipa Ekor Merah**

Remarks: Here we accept the correction of the type locality made by Schlegel (1844). We have failed to find another species of *Cylindrophis* sympatric with *C. ruffus* in Java among the specimens examined. However the biogeographical range of *C. ruffus* could extend beyond Java, e.g., Borneo and Peninsular Malaysia—see Stuebing (1994: Table 1).

Examined materials (14): MZB 1418, (SVL 715 mm), Burial, Bogor, West Java, Indonesia; MZB 3816, 1433, (SVL 325 mm, 350 mm), Banten, Indonesia; MZB 300, 301, 304, 309, 1049, 2000, (SVL 580 mm, 550

mm, 520 mm, 560 mm, 540 mm, 650 mm); MNHN-RA 1975.0073–74, 3280, 2007.2452 (formerly 3280A), 7182, (SVL 258 mm, 300 mm, 517 mm, 466 mm, 257 mm), Java, Indonesia.

Diagnosis: *Cylindrophis ruffus* is distinguished from all congeners by having the following characters: 19 midbody scale rows (vs. 17 in *C. engkariensis*; 21 in *C. isolepis*, *C. lineatus*, *C. maculatus*, *C. yamdena*; 23 in *C. aruensis*, *C. opisthorhodus*), 186–197 ventrals (vs. 233–275 in *C. melanotus*; 201–225 in *C. burmanus*), wide and constant bands encircling dark body (vs. dorsum uniform black with no cross bands in *C. boulengeri*; narrow and alternating bands on paler body in *C. burmanus*), an interrupted and wide band on the nape (vs. no ring on the nape in *C. boulengeri*; a complete and narrow ring encircling the nape in *C. burmanus*).

Description of examined materials: SVL 257–715 mm; body elongate, rounded in cross section; head not distinct from neck, broadened and dorsoventrally flattened in the orbital and sagittal regions; snout rounded in dorsal and lateral view.

Rostral shield large, somewhat visible from a dorsal perspective with a conical apex; a single nasal, widely in contact behind the rostral, no internasals; nasals in contact with rostral anteriorly, with prefrontal dorsally, and the first and second supralabials ventrally; nostrils large; canthus rostralis weakly defined; prefrontal somewhat larger than the frontal and quadrangular; frontal large, triangular, and length same as its width; supraocular wide, triangular, posteriorly wider; parietal small, triangular,

Table 3. Comparison of some morphometric, meristic, and morphological characters of *Cylindrophis* species which have 21 midbody scale rows, based on examined materials; “—” = Not applicable.

Character	21 scale rows at midbody					
	<i>C. isolepis</i> (<i>n</i> = 7)	<i>C. lineatus</i> (<i>n</i> = 2)	<i>C. maculatus</i> (<i>n</i> = 33)	<i>C. yamdena</i> (<i>n</i> = 5)	<i>C. jodiae</i> sp. nov. (<i>n</i> = 11)	<i>C. mirzae</i> sp. nov. (<i>n</i> = 4)
Location	Jampea	Borneo	Sri Lanka	Yamdena	Vietnam	Singapore
SVL (in mm)	320–500	540–713	262–378	500–610	146–656	220–693
Scale rows around neck	21–23	20–21	19 or 20	21	21	19
Scale rows around midbody	21	21	21	21	21	21
Scale rows around precloacal	19	19	16 or 17	17	15–18	17 or 18
Mid ventral scales	217–225	215–218	195–208	179–193	182–196	196–217
Subcaudals	5–6	6–8	4–6	5–7	4–7	4–7
Frontal > prefrontal (1) or < (0)	0	0	0	1	0	0
Pale band/ring on the nape present (1) or absent (0)	1	0	1	0	1	1
Pale band/ring wide (1) or narrow (0)	1	—	1	—	1	0
Pale band/ring complete (1) or dorsally interrupted (0)	0	—	0	—	0	0
Crossbands on the back present (1) or absent (0)	0	0	0	0	1	1
Crossbands complete (1) or interrupted	—	—	—	—	0	1
Crossbands constant (1) or alternating (0)	—	—	—	—	1	1
Crossbands wide (1) or narrow (0)	—	—	—	—	1	0

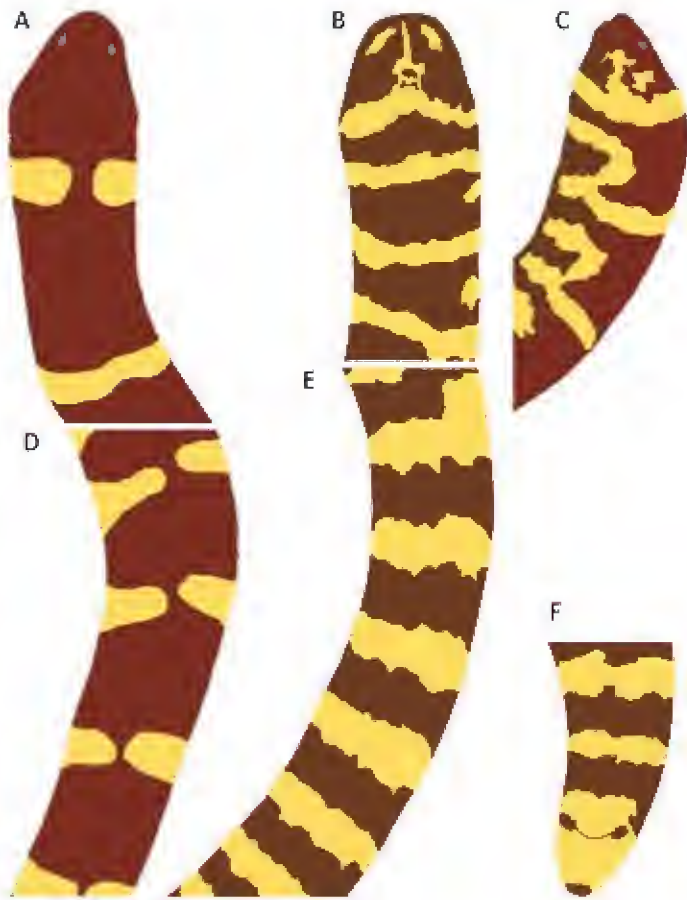


Fig. 1. Coloration of *Cyllindrophis ruffus* MZB 1418 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.



Fig. 2. Coloration of *Cyllindrophis burmanus* lectotype, BMNH 1940.3.3.1 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

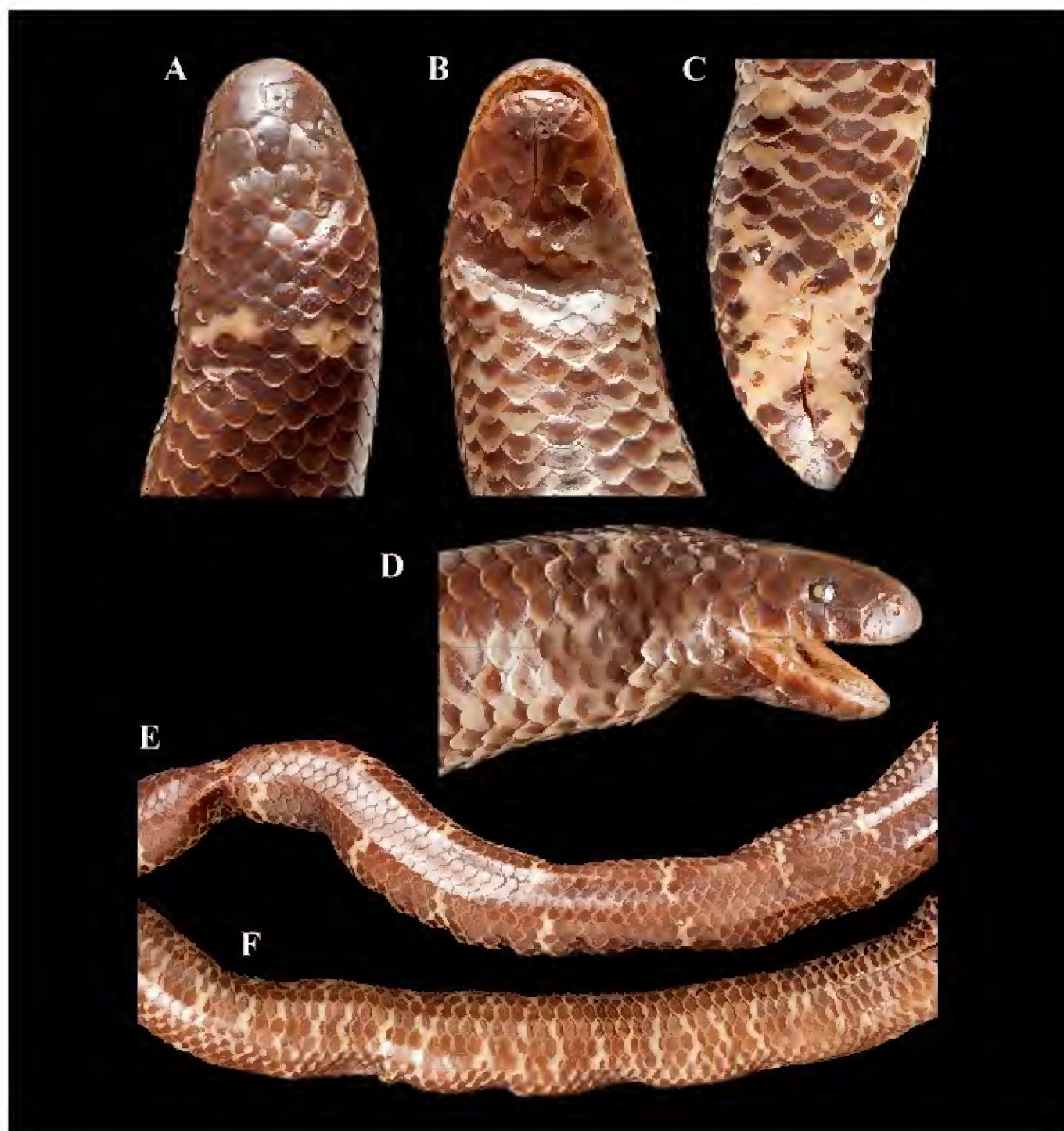


Fig. 3. Scalation of *Cyllindrophis burmanus* lectotype, BMNH 1940.3.3.1 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) tail in ventral view, (E) midbody in dorsal view, (F) midbody in ventral view.

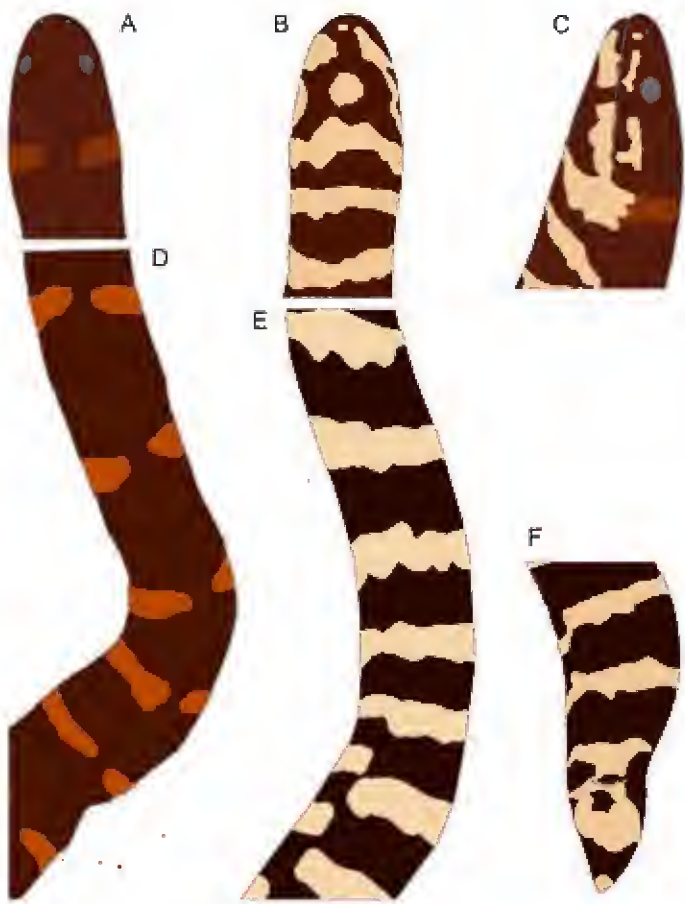


Fig. 4. Coloration of *Cylindrophis jodiae* sp. nov. holotype, MNHN-RA 1911.0196 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

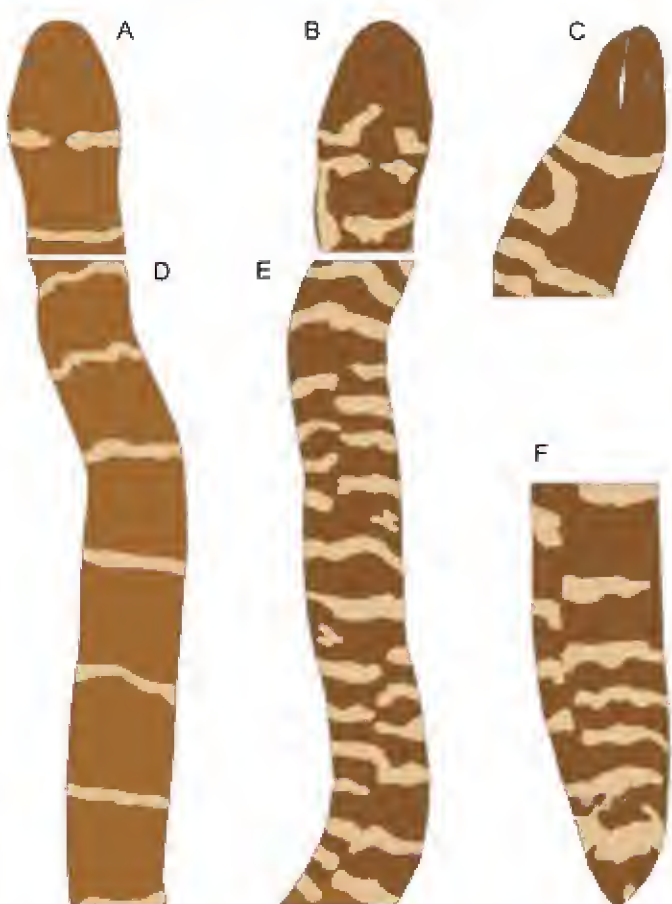


Fig. 6. Coloration of *Cylindrophis mirzae* sp. nov. holotype, MNHN-RA 3279 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.



Fig. 5. Scalation of *Cylindrophis jodiae* sp. nov. holotype, MNHN-RA 1911.0196 (A) head in dorsal view, (B) head in ventral view, (C) tail in ventral view, (D) head in lateral view, (E) tail in lateral view, (F) body in dorsal and ventrolateral view.

its rear border pointed, bordered by supraocular, frontal shield, upper posterior temporal shield, occipital shield, and two dorso-nuchal shields posteriorly on each side, the occipital shield is of equal size as other dorso-nuchal scales; loreal and preocular absent; eye small, pupil rounded; eye in broad contact with supraocular dorsally, prefrontal and third supralabial anteriorly, fourth supralabial ventrally, and postocular posteriorly; a single small postocular, quadrangular, posteriorly wider, in broad contact with supraocular, anterior temporal, and fourth supralabial; temporals 1+2, triangular; anterior temporal larger than posteriors; anterior temporal in contact with supraocular and both posterior temporal with parietal dorsally, 4th–6th supralabials ventrally; anterior temporal does not meet parietals.

Six supralabials, 3rd–5th larger in size; first supralabial in contact with rostral anteriorly and nasal dorsally; second supralabial in contact with nasal and prefrontal dorsally, third supralabial in contact with prefrontal and eye dorsally, fourth supralabial in contact with the eye, postocular, and anterior temporal dorsally; fifth supralabial in contact with anterior and posterior temporals; sixth supralabial in contact with lower posterior temporal dorsally and body scales posteriorly.

Mental small, triangular; first infralabial pair larger than mental plate and in broad contact with each other, in contact with anterior chin shield posteriorly; six infralabials in total, 1st–3rd in contact with first chin shield, 4th–6th in contact with gular scales, and not touching the chin shields; anterior chin shields larger than posterior ones; a mental groove continues from the posterior tip of the mental until the posterior chin shields.

Body slender; transverse dorsal scale rows (20–23)–19–(17–18), all smooth, subcycloid, and weakly imbricate; vertebrae and midventrals undifferentiated from adjacent scales; 186–197 ventrals; cloacal plate divided, precloacal undivided and triangular, tail extremely short, relative TL (TL/total length) 2.1–2.9%, with a conical robust and thick tip; 5–8 entire subcaudals.

Coloration: All the examined specimens have a reddish brown back with wide and incomplete lighter bands encircling the body along dorsal surface from behind nape to tail, each band covering about two scales; head entirely darker, an incomplete, wide ring encircling the nape; the venter is dark brown with regular, cream colored stripes, divided at midline. See Fig. 1 for details of coloration in preservative.

Distribution: *Cylindrophis ruffus* is recorded from Java, Indonesia (Fig. 8). Possible type locality is Batavia (now Jakarta) in Indonesia (not Batavia in Suriname).

***Cylindrophis burmanus* Smith 1943**

Cylindrophis rufus burmanus Smith 1943: 97
(Figs. 2, 3, 8; Tables 1, 2)

Proposed standard English name: **Burmese Pipe-Snake**

Lectotype (designated herein): BMNH 1940.3.3.1, (SVL 320 mm), collected from Rangoon, Burma (now Myanmar) by an unknown collector, collection date unknown. This specimen was presented to BMNH by Professor F.J. Meggitt, University College Rangoon (according to the museum registry). Although Smith (1943) had several specimens at his disposal at the time, he provided the measurement for only the largest specimen in the series. Because the original description is not comprehensive enough, and because of the fact that the *Cylindrophis* population in Myanmar may represent more than one species, in order to stabilize the name with a recognized type specimen, we here designate BMNH 1940.3.3.1 as the lectotype.

Paralectotypes (6): BMNH 1940.3.3.2, (SVL 212 mm), collected from Rangoon, Burma by an unknown collector, presented by F.J. Meggitt; BMNH 1908.6.23.3, (SVL 293 mm), Burma, collector and date unknown, presented by Major F. Wall; BMNH 1891.11.26.28, (SVL 280 mm), Pyinmana, Upper Burma, collector and date unknown, presented by E.W. Oates; BMNH 1925.4.2.2, (SVL 280 mm), Thandoung, Burma, collector and date unknown, presented by F. Wall; BMNH 1925.12.22.4, (SVL 256 mm), Sahmaw, Myitkyina District, Burma, collector and date unknown, presented by F. Wall; and probably ZMB 3094 (*vide* Iskandar and Colijn 2002; indicated no justification). All these paralectotypes share the same characters as the lectotype and belong to the same species.

Diagnosis: *Cylindrophis burmanus* is distinguished from all congeners by having the following characters: 19 midbody scale rows (vs. 17 in *C. engkariensis*; 23 in *C. aruensis*, *C. opisthorhodus*; 21 in *C. isolepis*, *C. lineatus*, *C. maculatus*, and *C. yamdena*), 201–225 ventrals (vs. 233–275 in *C. melanotus*; 193–200 in *C. boulengeri*; 186–197 in *C. ruffus*), narrow and alternating bands on paler body (vs. dorsum uniform black with no crossbands in *C. boulengeri*; wide, constant, dorsally interrupted bands encircling the dark body in *C. ruffus*), a complete and narrow ring encircling the nape (vs. no ring on the nape in *C. boulengeri*; a wide, dorsally interrupted band encircling the nape in *C. ruffus*).

Description of lectotype: SVL 320 mm, tail length 10 mm; body elongate, rounded in cross-section; head not distinct from neck, broadened and dorsoventrally flattened in the orbital and sagittal regions; snout rounded in dorsal and lateral view.

Rostral shield large, visible from above with a conical apex; a single nasal, widely in contact behind the rostral, no internasals; nasals in contact with rostral anteriorly, with prefrontal dorsally, and the first and second supralabials ventrally; nostrils large; canthus rostralis weakly

defined; prefrontal hexagonal, larger than frontal; frontal large, triangular, and longer than width; supraocular wide, triangular, wider posteriorly; parietal small, triangular, its rear border rounded, bordered by supraocular, frontal shield, upper posterior temporal shield, occipital shield, and two dorso-nuchal shields posteriorly on each side, the occipital shield smaller than other dorso-nuchal scales; loreal and preocular absent; eye small, pupil rounded; eye in broad contact with supraocular dorsally, prefrontal and third supralabial anteriorly, fourth supralabial ventrally, and postocular posteriorly; a single large postocular, subtriangular, posteriorly narrow, in broad contact with supraocular, anterior temporal, upper posterior temporal, and fourth supralabial; temporals 1+2, all triangular; anterior temporal smaller than upper posterior; anterior temporal in contact with both posterior temporals, 4th and 5th supralabials ventrally; anterior temporal does not meet parietals.

Five supralabials, 3rd and 4th largest in size; first supralabial in contact with rostral anteriorly and nasal dorsally; second supralabial in contact with nasal and prefrontal dorsally; third supralabial in contact with prefrontal and eye dorsally; fourth supralabial in contact with eye, postocular, and anterior temporal dorsally; fifth supralabial in contact with anterior and posterior temporals.

Mental small, triangular; first infralabial pair larger than mental plate and in broad contact with each other, in contact with anterior chin shield posteriorly; five infralabials in total, 1st–3rd in contact with first chin shield, 4th and 5th in contact with gular scales, and not touching the chin shields; anterior chin shields larger than posterior ones; a mental groove continues from the posterior tip of the mental until the posterior chin shields.

Body slender; transverse dorsal scale rows 19–19–17, all smooth, subcycloid, and weakly imbricate; vertebral and midventral scales undifferentiated from adjacent scales; 213 ventrals; cloacal plate divided, precloacal undivided and triangular, tail extremely short, relative TL (TL/total length) 3.0%, with a conical thick and robust tip; 6 or 7 (damaged) entire subcaudals.

Coloration: The lectotype (the largest specimen of the original syntypes) has a brown back with narrow and alternating white stripes along dorsal surface from behind nape to tail, each stripe covering about half of one scale; head entirely dark, a complete, narrow ring encircling the nape; the venter is brown with regular, mottled cream colored bars. See Fig. 2 for details of coloration in preservative.

Variation of paralectotypes: SVL range from 256–293 mm; body scale rows at neck ranges from 17–19; ventrals 201–225; relative TL 2.1–2.9%.

Distribution: *Cylindrophis burmanus* is only reported from Myanmar (Fig. 8).

***Cylindrophis jodiae* sp. nov. Amarasinghe, Ineich, Campbell & Hallermann**

(Figs. 4, 5, 8; Table 3)

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Proposed standard English name: **Jodi's Pipe-Snake**

Holotype: MNHN-RA 1911.0196, SVL 415 mm, collected from Annam, Central Vietnam, by the French botanist Philippe Eberhardt, without precise date, but before 1911.

Paratypes (10): MNHN-RA 1974.1251, (SVL 391 mm), collected in the area of Saigon, southern Vietnam, by Sergeant Poilane before 1974; MNHN-RA 1885.0100–103, (SVL 265, 264, 146, 177 mm), collected in Cochinchina, southern Vietnam, by Girard before 1885; MNHN-RA 1885.0098–99, (SVL 375, 656 mm), collected in Cochinchina, southern Vietnam, by Girard before 1885; MNHN-RA 1935.0001, (SVL 271 mm), collected in Cochinchina, southern Vietnam, by René Bourret before 1935; MNHN-RA 1974.1253, (SVL 192 mm), collected in the area of Saigon, southern Vietnam, by Sergeant Poilane before 1974; BMNH 1920.1.20.2649, (SVL 345 mm), collected from Long-Xuyen, Vietnam by F. Lataste, collection date unknown.

Diagnosis: *Cylindrophis jodiae* sp. nov. is distinguished from all congeners by having the following characters: 21 midbody scale rows (vs. 17 in *C. engkariensis*; 19 in *C. boulengeri*, *C. burmanus*, *C. melanotus*, *C. ruffus*; 23 in *C. aruensis*, *C. opisthorhodus*), 182–196 ventrals (vs. 217–225 in *C. isolepis*), wide and interrupted bands on the back (vs. lateral and middorsal stripes along the body in *C. lineatus*; two series of large reddish-brown spots along the back, which are enclosed by a black network in *C. maculatus*; no bands and paler back in *C. yamdena*).

Description of holotype: An adult, SVL 420 mm, tail length 10.1 mm; body elongate (largest body diameter at midbody is 23.8 mm), flattened laterally in cross section; head not distinct from neck, broadened and dorsoventrally flattened in the orbital and sagittal regions; snout rounded in dorsal and lateral view.

Rostral shield large, visible from above with a conical apex; a single nasal, widely in contact behind the rostral, no internasals; nasals in contact with rostral anteriorly and prefrontal posteriorly, and the first and second supralabials ventrally; the holotype has its right nasal in contact with the left prefrontal by a point, which is an anomaly; nostrils large; canthus rostralis weakly defined; prefrontals slightly larger than the frontal, and pentagonal; frontal small, triangular, and same length as its width (length 3.8 mm, width 3.7 mm), equal or somewhat smaller than supraocular; supraocular wide, subtriangular, wider posteriorly; parietals smaller than frontal



Fig. 7. Scapulation of *Cylindrophis mirzae* sp. nov. holotype, MNHN-RA 3279 (A) head in dorsal view, (B) head in ventral view, (C) tail in ventral view, (D) head in lateral view, (E) tail in lateral view, (F) body in dorsal view, (G) body in ventral view.

which are in large median oblique contact oriented from right to left antero-posteriorly, subtriangular, their rear border bluntly pointed, bordered by supraoculars, frontal shield, upper posterior temporal shields, occipital shield, and two dorso-nuchal shields posteriorly on each side, the occipital shield of the same size as other dorso-nuchal scales; left parietal in larger contact than the right (just a point) with the frontal; loreal and preocular absent; eye small (diameter 1.8 mm), pupil rounded; eye in broad contact with supraocular dorsally, prefrontal and third supralabial antero-ventrally, fourth supralabial ventrally, and postocular posteriorly; a single postocular, quadrangular, posteriorly roundish and wider, in broad contact with supraocular, anterior temporal, and narrow contact with fourth supralabial; temporals 1+2, triangular; anterior temporal larger than posteriors; anterior temporal in contact with supraocular and posterior temporal dorsally, 4th and 5th supralabials ventrally, anterior temporal does not meet parietal on both sides; upper posterior temporal slightly larger than lower posterior temporal.

Five supralabials, 3rd–5th larger in size; first supralabial in contact with rostral anteriorly and nasal dorsally; second supralabial in contact with nasal and prefrontal

dorsally; third supralabial in contact with prefrontal and eye dorsally; fourth supralabial in contact with the eye, postocular, and anterior temporal dorsally; fifth supralabial in contact with anterior and posterior temporals dorsally and body scales posteriorly.

Mental small, triangular; first infralabial pair larger than mental plate and in broad contact with each other; 1st infralabials in contact with anterior chin shield posteriorly; five infralabials in total, 1st–3rd in contact with first chin shield, 4th and 5th in contact with gular scales and not touching the chin shields; anterior chin shields larger than posterior ones; a mental groove continues from the posterior tip of the mental until the posterior chin shields.

Body slender; transverse body scale rows 21–21–17, all smooth, subcycloid, and weakly imbricate; vertebral and midventral scales undifferentiated from adjacent scales; 188 ventrals; cloacal plate divided, precloacal undivided and triangular; tail extremely short, relative TL (TL/total length) 2.5%, with a conical robust and thick tip, and six paired subcaudals.

Coloration: The holotype has a dark brown back with wide and interrupted white bands along dorsal surface

from behind nape to tail, each band covering about two scales; head entirely dark, an incomplete, wide band encircling the nape; the venter is dark brown with regular, cream colored bars, divided at midline. See Fig. 4 for details of coloration in preservative.

Variation of paratypes: SVL range from 146–656 mm, but MNHN-RA 1885.0102–3, 1974.1253 are juveniles; body scale rows at one scale prior to precloacal ranges from 16–18; ventrals 182–196; subcaudals 4–6; all the subcaudals entire except MNHN-RA 1885.0100 (2nd divided), MNHN-RA 1885.0103 (3rd divided); relative TL 2.0–3.3%.

Etymology: The species epithet is an eponym latinized as a noun in the genitive singular, honoring Dr. Jodi Rowley for her generous friendship, and remarkable contributions and expeditions assessing amphibian decline due to various diseases, conservation status, and in documenting amphibian biodiversity. Jodi Rowley is an Australian herpetologist. She has conducted amphibian research in Southeast Asia, mainly in Vietnam. Currently she is a co-ordinator of Australian Museum Research Institute, a member of the IUCN Amphibian Red List Authority and the co-chair for Mainland Southeast Asia of the IUCN Species Survival Commission Amphibian Specialist Group.

Distribution: The new species is only reported from Vietnam (Fig. 8). The specimens from Cambodia and

Thailand are much closely related to this new species, however for the moment we exclude these specimens as it seems now, after having examined these specimens, that there may be many more species in existence in Cambodia and Thailand.

***Cylindrophis mirzae* sp. nov. Amarasinghe, Ineich, Campbell & Hallermann**

(Figs. 6, 7, 8; Table 3)

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Proposed standard English name: **Mirza's Pipe-Snake**

Proposed standard Indonesian name: **Ular Pipa Mirza**

Holotype: MNHN-RA 3279, (SVL 419 mm), collected at Singapore, by Joseph Fortuné Théodore Eydoux (1802–1841), certainly during the expedition on the vessel *La Favorite* (1829–1832).

Paratypes (3): BMNH 1847.2.9.23, (SVL 693 mm), collected from Singapore, by A.F. Gardiner, collection date unknown; BMNH 1938.9.8.1, (SVL 580 mm), collected from Singapore, by Dr. A.G.H. Smart (Assistant Medical Advisor, Colonial Office S.W.1.), presented by Dr. H.B. Newham (London School of Hygiene and Tropical Medicine), collection date unknown; BMNH 1880.9.10.23, (SVL 298 mm), collected from Singapore, collector and the date unknown, presented by Dr. Dennis.

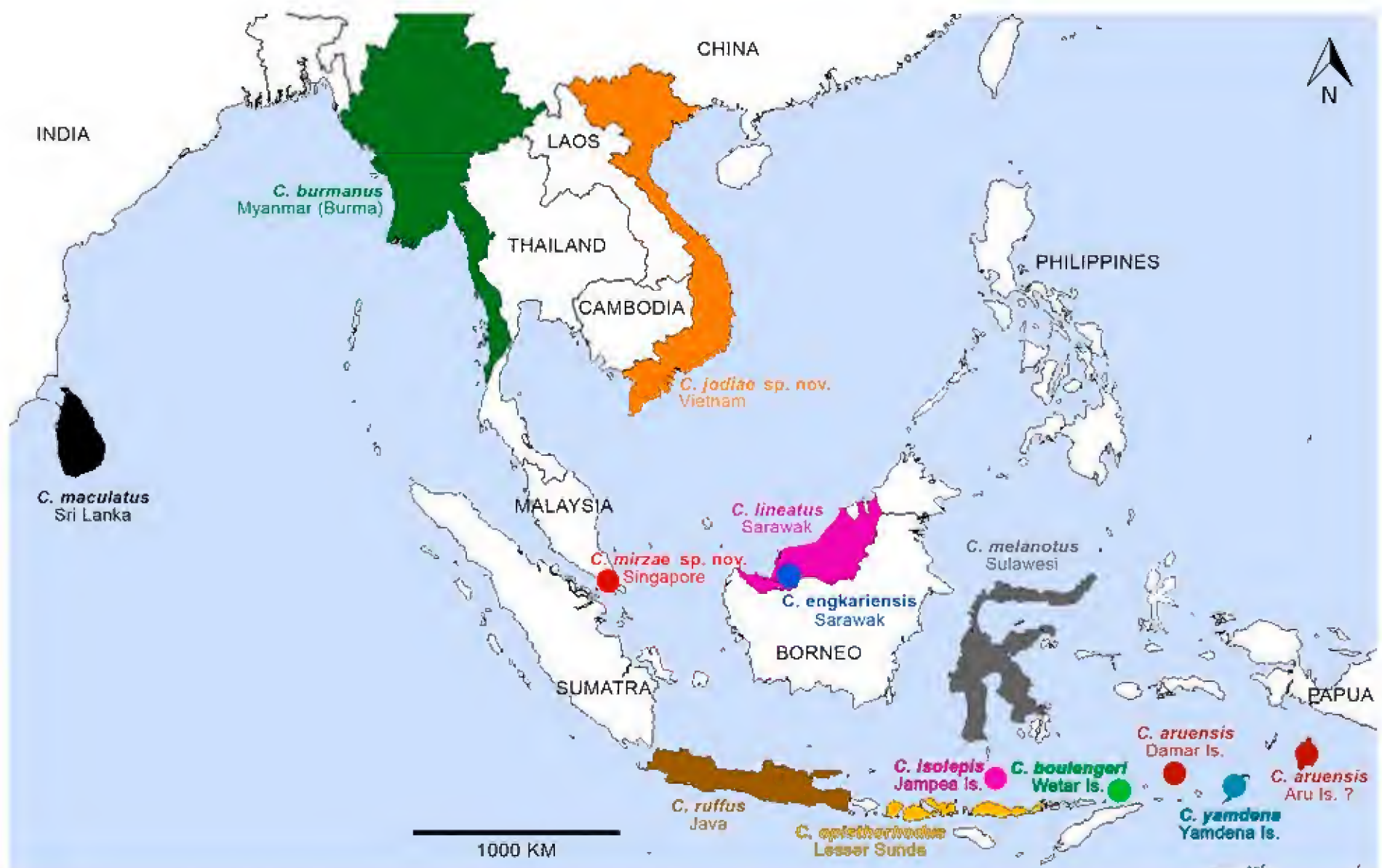


Fig. 8. Current distribution pattern of the genus *Cylindrophis*.

Diagnosis: *Cylindrophis mirzae* sp. nov. is distinguished from all congeners by having the following characters: 21 midbody scale rows (vs. 17 in *C. engkariensis*; 19 in *C. Boulengeri*, *C. burmanus*, *C. melanotus*, *C. ruffus*; 23 in *C. aruensis*, *C. opisthorhodus*), narrow and completed lighter rings encircling the dark body at anterior and posterior parts of the body (vs. no bands on the paler back in *C. isolepis* and *C. yamdena*; lateral and middorsal stripes along the body in *C. lineatus*; wide and interrupted bands on the back in *C. jodiae* sp. nov.; two series of large reddish-brown spots along the back, which are enclosed by a black network in *C. maculatus*).

Description of holotype: An adult, SVL 419 mm, tail length 10.0 mm; body elongate (largest body diameter at midbody is 14.6 mm), rounded in cross section; head not distinct from neck, broadened and dorsoventrally flattened in the orbital and sagittal regions; snout blunt in dorsal and lateral view.

Rostral shield small, slightly visible from above with a conical apex; a single nasal, widely in contact behind the rostral, no internasals; nasals in contact with rostral anteriorly, with prefrontal posteriorly, and the first and second supralabials ventrally; nostrils large; canthus rostralis weakly defined; prefrontals larger than the frontal, and quadrangular; frontal large (length 2.7 mm and width 3.1 mm), triangular, and with the same length as width, equal or somewhat larger than supraocular; supraocular wide (length 2.6 mm and width 2.3 mm), triangular, posteriorly wider; parietals equal in size to frontal, subtriangular, their rear border rounded, bordered by supraocular, frontal shield, upper posterior temporal shield, occipital shield, and two dorso-nuchal shields posteriorly on each side, the occipital shield is of same size as other dorso-nuchal scales; loreal absent; no preocular; eye small (diameter 1.0 mm), pupil rounded; eye in broad contact with supraocular dorsally, prefrontal and third supralabial anteriorly, fourth supralabial ventrally, and postocular posteriorly; a single postocular, trapezoidal, posteriorly wider, in broad contact with supraocular, anterior temporal, and wide contact with fourth supralabial ventrally; temporals 1+2, subtriangular; anterior temporal much larger than posteriors; anterior temporal in contact with supraocular and upper posterior temporal dorsally, lower posterior temporal posteriorly, 4th and 5th supralabials ventrally; anterior temporal well separated from the parietal by the supraoculars and the upper posterior temporal.

Six supralabials, 3rd and 4th larger in size and touching the eye; first supralabial in contact with rostral anteriorly and nasal dorsally; second supralabial in contact with nasal and prefrontal dorsally, third supralabial in contact with prefrontal and eye postero-dorsally, fourth supralabial in contact with the eye, postocular, and anterior temporal dorsally; fifth supralabial in contact with anterior and lower posterior temporal dorsally; sixth supralabial in contact with posterior temporals dorsally and body scales posteriorly.

Mental large, triangular; first infralabial pair slightly smaller than mental plate and in narrow contact with each other, and with anterior chin shield posteriorly; six infralabials in total, 1st–3rd in contact with first chin shield, 4th–6th in contact with gular scales but not touching the chin shields; anterior chin shields larger than posterior ones; a mental groove continues from the posterior tip of the mental until the posterior chin shields.

Body slender; transverse body scale rows 19–21–18, all smooth, subcycloid, and weakly imbricate; vertebrals and midventrals undifferentiated from adjacent scales; 213 ventrals; cloacal plate divided, precloacal undivided and triangular; tail extremely short, relative TL (TL/total length) 2.3%, with a conical robust and thick tip; five subcaudals, the first three entire, the following divided and the last one entire again.

Coloration: The holotype has a brown back with narrow and completed lighter rings encircling the body along dorsal surface from behind nape to tail, each band covering about one scale; head lighter, an incomplete, narrow ring encircling the nape; the venter is dark brown with regular, cream colored stripes, some divided at midline. See Fig. 6 for details of coloration in preservative.

Variation of paratypes: SVL range from 298–693 mm; ventrals 196–217; six subcaudals in all paratypes; relative TL 2.0–3.3%.

Etymology: The species epithet is an eponym latinized as a noun in the genitive singular, honouring Dr. Mirza Kusri for her generous friendship and support, for her dedication and important contributions to herpetological conservation and ecology in Indonesia. Mirza Kusri is an Indonesian herpetologist and currently she is a lecturer at Bogor Agricultural University, Indonesia and a steering committee member of IUCN Species Survival Commission Amphibian Specialist Group.

Distribution: The new species is evidently recorded from Singapore (Fig. 8).

Discussion

Although, it has been confirmed that the types of *Anguis ruffa* and *Cylindrophis resplendens* are lost, it is now clear that the type locality of *Cylindrophis ruffus* is Java (*vide* Schlegel 1844). The International Code of Zoological Nomenclature (ICZN) supports the designation of a neotype in order to stabilize the taxonomic status. However, we have decided not to undertake such action due to the following reasons: (1) our available samples from Java were too small ($n = 14$), (2) we have not yet compared the *C. cf. ruffus* populations (which also have 19 midbody scale rows) from other Sundaic Islands and Peninsular Malaysia (including specimens mentioned by

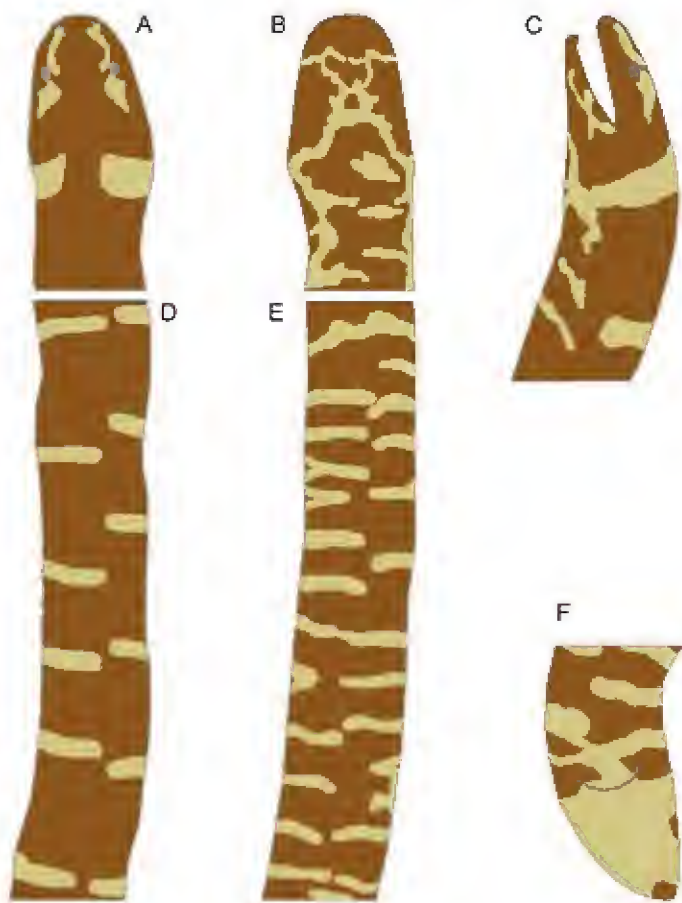


Fig. 9. Coloration of *Cylindrophis aruensis* syntype BMNH 1946.1.16.72 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

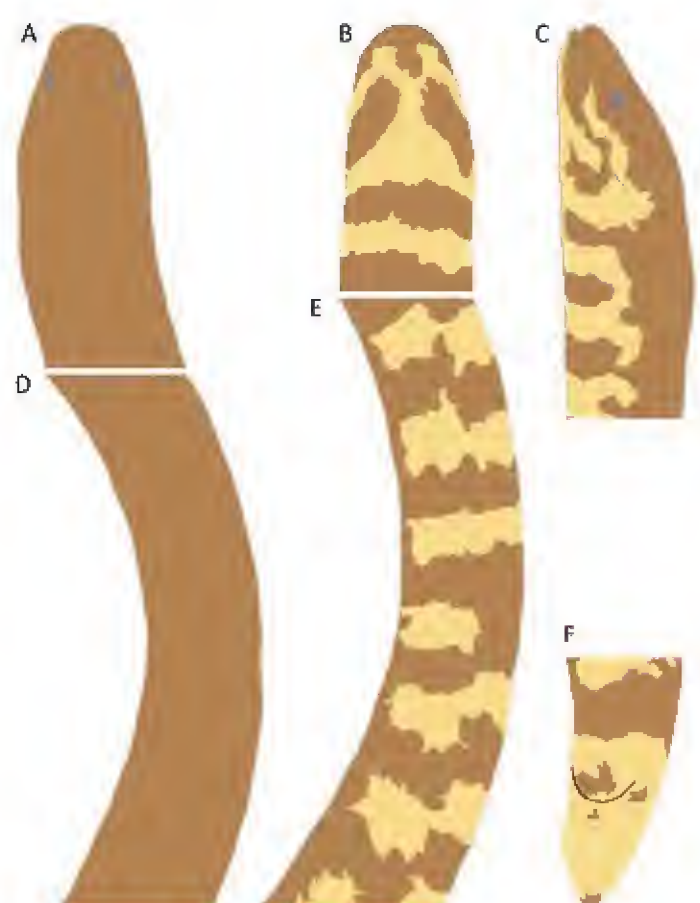


Fig. 10. Coloration of *Cylindrophis boulengeri* MZB 5284 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.



Fig. 11. Coloration of *Cylindrophis engkariensis* holotype ZRC 8821 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

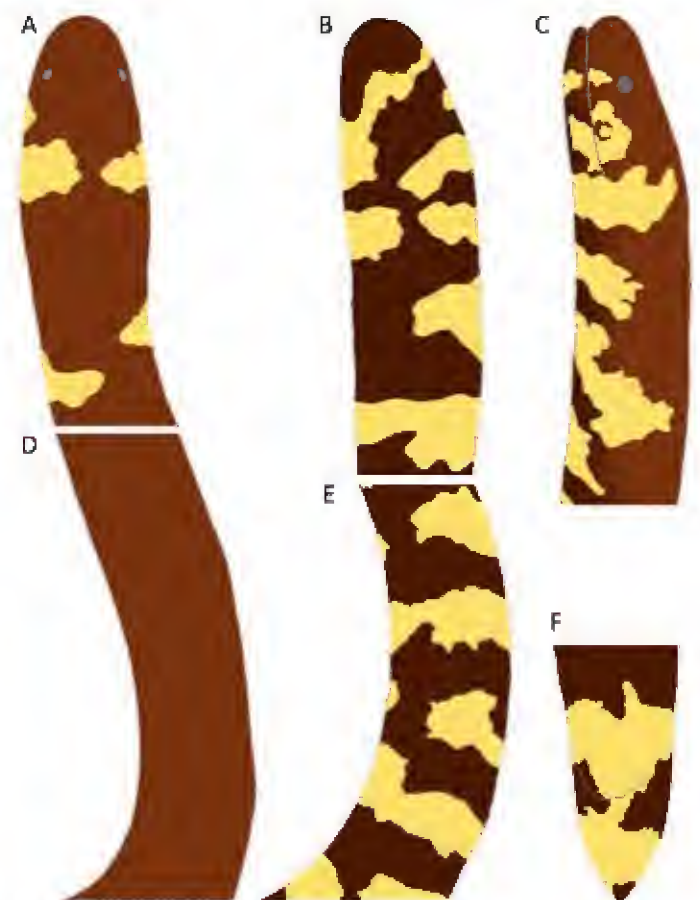


Fig. 12. Coloration of *Cylindrophis isolepis* MZB 1926 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

Stuebing 1994), and (3) we have not found a preserved adult specimen from Jakarta with associated DNA samples to support its designation as a neotype. We believe it would be better to designate a specimen of which DNA samples are available to solve the taxonomic issues mentioned in number (2) above.

Based on morphological and meristic characters, particularly the number of dorsal scale rows at midbody,

number of ventrals, and coloration, we include *C. rufus* and *C. burmanus* in the morphological group which has 19 middorsal scale rows. However Taylor's (1965) specimen of "*Cylindrophis rufus rufus*" from Thailand and the populations from Thailand and Cambodia might either represent an undescribed species or represent *C. jodiae* sp. nov. which is distributed in Vietnam. However, we defer from attempting to answer such questions

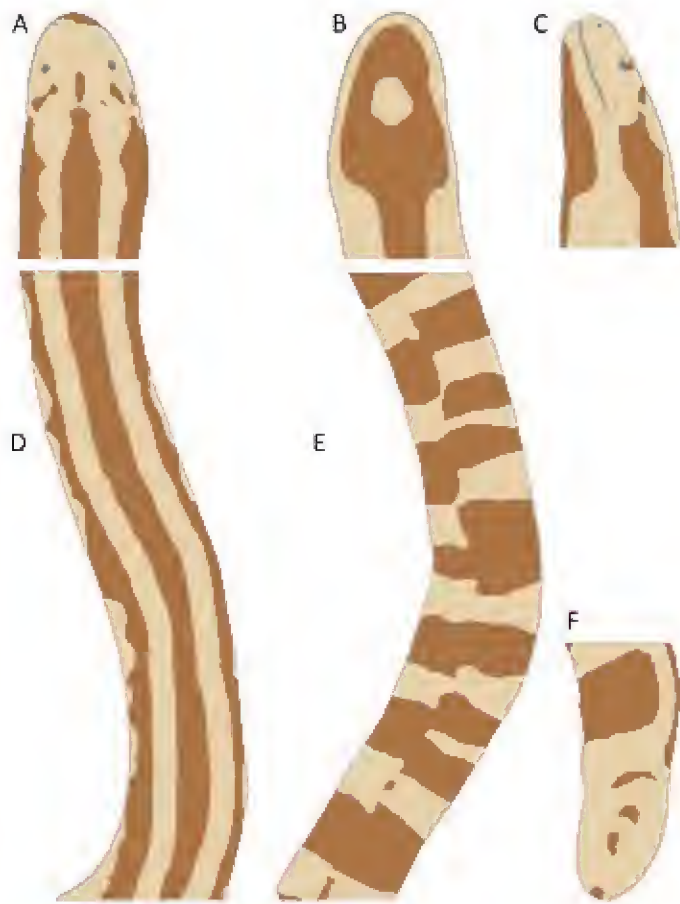


Fig. 13. Coloration of *Cylindrophis lineatus* holotype BMNH 1946.1.16.5 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

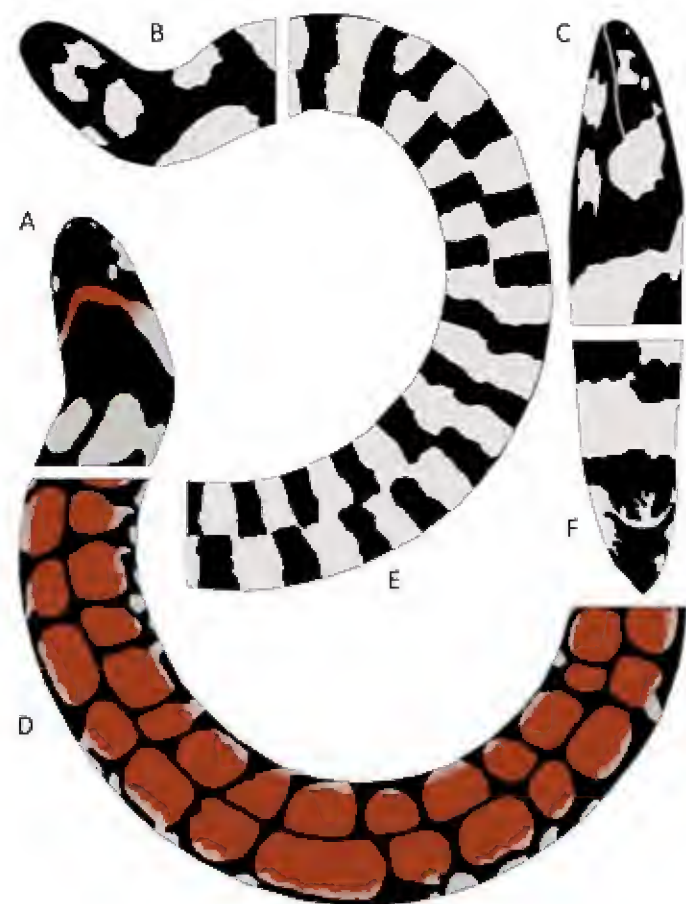


Fig. 14. Coloration of *Cylindrophis maculatus* BMNH 1962.861 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.



Fig. 15. Coloration of *Cylindrophis melanotus* MZB 2999 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

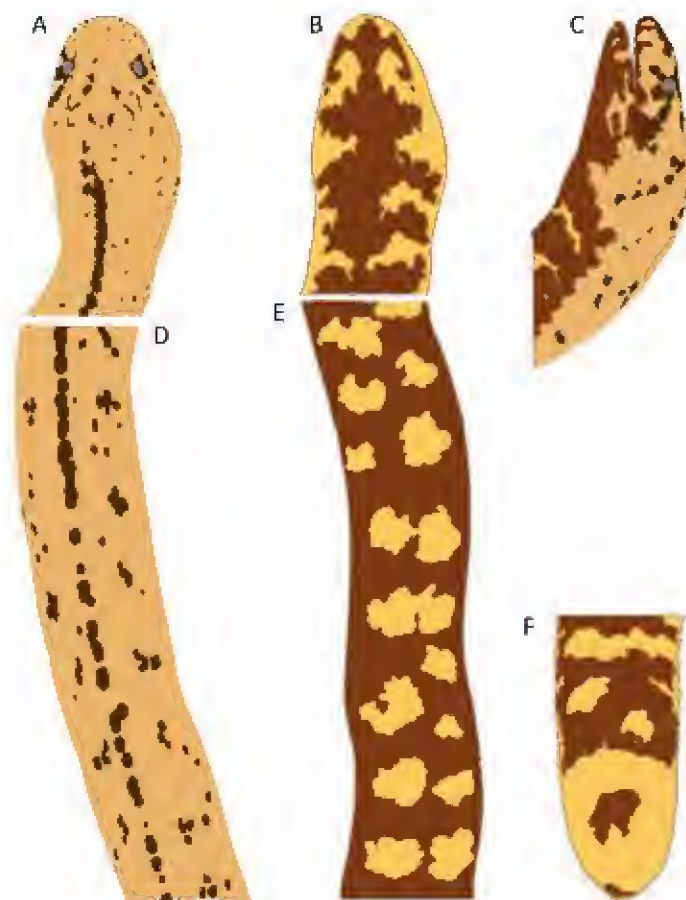


Fig. 16. Coloration of *Cylindrophis opisthorhodus* MZB 1515 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

because we believe such questions should be addressed with the support of molecular evidence and with the comparison involving large samples from each of the representative countries. We did not compare *C. mirzae* sp. nov. from Singapore with the populations in Sumatra, Peninsular Malaysia, and Borneo because the available samples from those locations were too small, thus we have voluntarily excluded those areas from our study. It

is probable that *C. mirzae* sp. nov. may be distributed in some parts of Sumatra (e.g., *C. cf. mirzae* specimen listed in Appendix 1 below).

It seems also that *Cylindrophis melanotus* might be a species complex or at least consisting of two cryptic species (note the wide range of ventrals: 233–275). Although, the taxonomy of the genus *Cylindrophis* should be examined critically with larger samples and with the

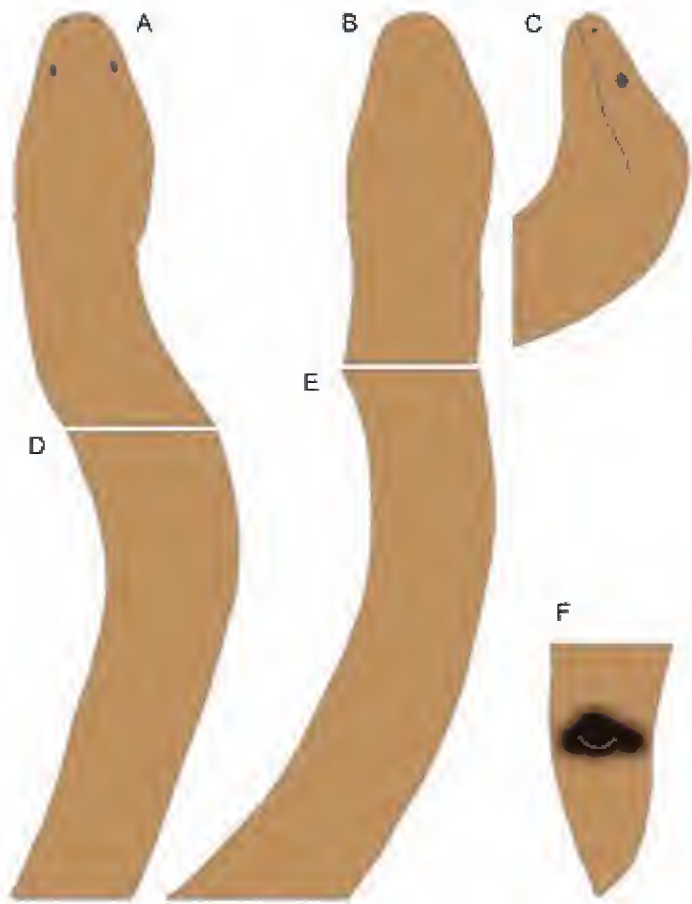


Fig. 17. Coloration of *Cylindrophis yamdena* holotype WAM R112252 (A) head in dorsal view, (B) head in ventral view, (C) head in lateral view, (D) midbody in dorsal view, (E) midbody in ventral view, and (F) tail in ventral view.

support of molecular analyses (especially for the species which have 19 and 21 midbody scale rows), we have described the above two new species due to their clear morphological differences and because of their biogeographically isolation from all other known taxa.

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Appendix 1

Comparative materials examined

Cylindrophis aruensis Boulenger, 1920 (Fig. 9) – Aru Island, Indonesia: BMNH 1946.1.16.72–73 (syntypes); Dammer Island, Indonesia: MZB 305.

Cylindrophis boulengeri Roux, 1911 (Fig. 10) – Ilwaki, Wetar Island, Barat Daya, Maluku, Indonesia: SMF 16996 (holotype), MZB 5243, 5284; Madura Island, East Java, Indonesia (doubtful location): MZB 314.

Cylindrophis engkariensis Stuebing, 1994 (Fig. 11) – Nanga Segerak, Sarawak, Malaysia: ZRC 8821 (holotype).

Cylindrophis isolepis Boulenger, 1896 (Fig. 12) – Jampea Island, Selayar, South Sulawesi, Indonesia: BMNH 1946.1.1.47 (holotype); MZB 299A–B, 1926, 3149, 3365–66.

Appendix 1 (continued)

Cylindrophis cf. *jodiae* – Trapeang-Chan, Cambodia: MNHN-RA 1970.0411–13; Snoc Trou, Cambodia: MNHN-RA 1963.0713; Trabeang Thum lake, Choam Khsant, Cambodia: MNHN-RA 2010.0909; Ban Chao Samran, Muang District, Thailand: MNHN-RA 1998.0576; Ban Pong, Thailand: MNHN-RA 1999.7634; Ban Bang Ba, Muang District, Phang Nga Province, Thailand: MNHN-RA 1997.6582; Bangkok, Thailand: MNHN-RA 3281; Thailand: BMNH 1865.4.28.17, 1897.10.8.18, 1947.1.1.8, 1969.324, 1969.819, 1969.1693, 1987.1723–24.

Cylindrophis lineatus Blanford, 1881 (Fig. 13) – Singapore: BMNH 1946.1.16.5 (holotype); Borneo: BMNH 1901.5.17.1.

Cylindrophis maculatus Linnaeus, 1758 (Fig. 14) – Sri Lanka: BMNH 1962.861, 1892.11.3.3, 1969.2755, 1968.77, 1905.3.25.76–81, 1894.9.11.5–7, 1845.8.7.5, 1897.10.20.18, 1931.5.13.1–5, 1915.5.3.1, 1930.5.8.48, 1930.5.8.51, 1930.5.8.50, 1930.5.8.49, 1930.5.8.52, 1962.254, 1964.1632–1633, 1964.1687; MNHN-RA 3282–83.

Cylindrophis melanotus Wagler, 1830 (Fig. 15) – Dumoga West, North Sulawesi, Indonesia: MZB 3246; Manado, North Sulawesi, Indonesia: MNHN-RA 5779, 1999.8281; Rantepao, North Toraja, South Sulawesi, Indonesia: MZB 3826; Majene, West Sulawesi, Indonesia: MZB 310; Lindu Lake, Tomado, Central Sulawesi, Indonesia: MZB 1553, 3621; Butung Island, South-East Sulawesi, Indonesia: MZB 2834, 2999; Tinanggea, South Konawe, South East Sulawesi, Indonesia: MZB 4567; Tinukari, Wawo, North Kolaka, South East Sulawesi, Indonesia: MZB 4568; Halmahera (=Halmahera), Indonesia: ZMB 34313 (holotype of *Cylindrophis heinrichi*); Sulawesi, Indonesia: MNHN-RA 3278, 7180, 7180A.

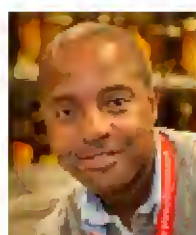
Cylindrophis cf. *mirzae* – Sumatra: MNHN-RA 1884.0115.

Cylindrophis opisthorhodus Boulenger, 1897 (Fig. 16) – Lombok, Indonesia: BMNH 1946.1.16.148–149 (syntypes); Ruteng, Watu, Manggarai, East Nusa Tenggara, Indonesia: MZB 1286; Flores, East Nusa Tenggara, Indonesia: MZB 1515; Ndao Nuse, West Rote, Rote Ndao, East Nusa Tenggara, Indonesia: MZB 1532.

Cylindrophis yamdena Smith & Sidik, 1998 (Fig. 17) – Yamdena Island, Indonesia: WAM R112252 (holotype), 109947, 109971–72, 109980.



A. A. Thasun Amarasinghe is an Indonesian resident and herpetologist with a special interest in the patterns and processes of speciation. He has been carrying out reptile taxonomy work in South and Southeast Asia since 2005, mainly focussing on the following geographic regions: Sri Lanka, India, Andaman/Nicobar, and Indonesia. He is the editor-in-chief of *TAPROBANICA* the Journal of Asian Biodiversity (ISSN: 1800-427X) which is now regarded as a leading journal for biodiversity and conservation in the tropical Asian region. As a conservationist, he has a strong commitment to furthering the IUCN's vision and mission. He is a commission member of the following IUCN committees: CEM South East Asia including thematic groups and the IUCN Species Survival Commission (Amphibian Specialist Group and Crocodile Specialist Group). He is currently a research scientist at the Research Center for Climate Change, University of Indonesia, Depok, Indonesia.



Patrick D. Campbell is a British citizen and Senior Curator of Reptiles, managing over an estimated 174,000 herpetology specimens in the Natural History Museum (London) at which he has been employed for almost 30 years. He is interested in collection management, reptile taxonomy, and the processes of speciation. He has carried out herpetological fieldwork recently in Kenya and the French Guiana and is also interested in the reptilian fauna of South and Southeast Asia, mainly focussing on the countries of Sri Lanka, India, Andaman/Nicobar, and Indonesia. As a BSAC (British Sub Aqua Club) advanced trained professional diver and dive instructor, he has dived on various expeditions including the RAF lead Benthic Orchid III examining the effect of the 2004 Tsunami in the Similan Islands Thailand, conducting underwater surveys for the burrowing starfish *Astropecten* in Spain, conducting marine biological surveys in the Cliffe Lagoons/Portland Harbour UK sifting and identifying macro invertebrate samples, and investigating shallow subtitle hydrothermal vents off the Greek island of Milos. He has lead various collection improvement projects at the museum including the recent CSIP (Collection Storage Improvement Project) Wildebeest project involving over 20,000 specimens.



Jakob Hallermann studied biology at the Universities of Tübingen and Hamburg, and then completed his Ph.D. in 1994 at the University of Tübingen focussing on the morphology of the Iguanian nose including a phylogenetic analysis. After two years as a volunteer at the Museum of Natural History Stuttgart, he became the curator of the herpetological collection of the Zoological Museum Hamburg (now Centre of Natural History, Cenak). His scientific interests are systematics, biogeography, speciation, and the comparative anatomy of herpetofauna. Since 1997 his research focus has shifted to the South and Southeast Asian herpetofauna. He has described many new species of the agamid lizard genera *Calotes*, *Pseudocalotes*, and *Bronchocela*. Currently, he is conducting research on the phylogeny of the African house snake genus *Boaedon*.



Irvan Sidik was born in Bandung, West Java Province, Indonesia. Irvan obtained an M.Sc. in the field of phylogenetics at the Institute Technology of Bandung. Since 1992 Irvan has been working as a staff researcher in the laboratory of herpetology at the Museum Zoologicum Bogoriense, Indonesian Institute of Sciences (LIPI) in the Cibinong Science Center. Beginning as an auxiliary field survey researcher, and then as a local CITES officer, Irvan became interested and developed a great interest in the snakes of the region of Sundaland. Irvan has continued with more scholarly work on the mountainous areas of the western part of Indonesia. Irvan's research is based on museum collections of specimens and field research in Indonesia's regions mentioned above. Irvan has been involved in several international research collaborations, and is currently working with the University of Texas at Arlington, USA on research of amphibians and reptiles in the mountains of Java and Sumatra. Irvan has published on the herpetofauna of Kalimantan and his first book was about snakes that are traded in Indonesia (CITES appendices I, II, and III) written in Indonesian. Currently, Irvan is studying the phylogeography of the reed snake genera *Calamaria* for his Ph.D. at the University of Brawijaya, Malang.



Jatna Supriatna is the chairman of Research Centre for Climate Change, University of Indonesia. Jatna is one of the leading research biologists, primatologists, and conservationists in Indonesia. He serves as a senior lecturer of the Biology Department, and a coordinator for the Graduate Program on Conservation Biology of the University of Indonesia. He has practiced as an editor for many international journals. In 2007 he was assigned as the chairman of the IUCN/SSC PSG South East Asia. He served on several assignments including those for the government of Indonesia: the National Research Council, the Steering Committee on Biodiversity Action Plan (Ministry of Planning), and the Biodiversity Taskforce (Ministry of Research & Technology). For his dedication to conservation, he received the Golden Ark Award (1999) from his royal highness Prince of Bernhard of the Netherlands. He also has received "the Habibie Award" (1999) from the Indonesian president. He has published ten books, mostly on Indonesia's biodiversity conservation, as well as over 100 research articles in journals such as *Science*, *Nature*, *Conservation Biology*, *Primates*, *Evolution*, *Primate Conservation*, *Herpetologica*, and others.



Ivan Ineich is a French herpetologist especially interested in systematics, biogeography, and processes of speciation. He has mostly been carrying out reptile taxonomy work in Africa and on the Pacific Islands, but also South and Southeast Asia. He was curator of lizards and snakes at Paris Natural History Museum (NNHN) from 1988 to 2014. He was editor-in-chief of the French *Bulletin de la Société Herpétologique de France* for many years. He is currently researcher at the Institute for Systematic, Evolution and Biodiversity at the Museum national d'Histoire naturelle of Paris, a position that he occupied since 1988.

In accordance with the International Code of Zoological Nomenclature new rules and regulations (ICZN 2012), we have deposited this paper in publicly accessible institutional libraries. The new species described herein has been registered in ZooBank (Polaszek 2005a, b), the official online registration system for the ICZN. The ZooBank publication LSID (Life Science Identifier) for the new species described here can be viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/." The LSID for this publication is: urn:lsid:zoobank.org:pub:A4C569A0-36DB-4E6D-B3CE-35331FE535F2.

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COVER: An adult individual of Canelos Treefrog (*Ecnomiohyla tuberculosa*) collected in a tree hole during a herpetological survey, carried out by the Field Museum, in the Putumayo basin at the Peruvian Amazonia. The Canelos Treefrog is one of the most enigmatic Neotropical frogs and its occurrence has been documented at scattered localities along the upper Amazon basin of Brazil, Colombia, Ecuador, and Peru. Although the phylogenetic position and natural history of this species remains a mystery, it is currently under investigation by a team of herpetologists from Ecuador and Peru led by Dr. Santiago Ron. *Photograph: Pablo J. Venegas.*

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